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THE GENESIS OF SUPERSTITIONS.[1]

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COMPREHENSION of the thoughts generated in the primitive man by his converse with the surrounding world can be had only by looking at the surrounding world from his stand-point. The accumulated knowledge and the mental habits slowly acquired during education must be suppressed, and we must divest ourselves of conceptions which, partly by inheritance and partly by individual culture, have been rendered necessary. None can do this completely, and few can do it even partially.

It needs but to observe what unfit methods are adopted by educators, to be convinced that even among the disciplined the power to frame thoughts which are widely unlike their own is extremely small. When we see the juvenile mind plied with generalities while it has yet none of the concrete facts to which they refer—when we see mathematics introduced under the purely rational form, instead of under that empirical form with which it should be commenced by the child, as it was commenced by the race—when we see a subject so abstract as grammar put among the first instead of among the last, and see it taught analytically instead of synthetically; we have ample evidence of the prevailing inability to conceive the ideas of undeveloped minds. And, if, though they have been children themselves, men find it hard to rethink the thoughts of the child, still harder must they find it to rethink the thoughts of the savage. To keep out automorphic interpretations is beyond our power. To look at things with the eyes of absolute ignorance, and observe how their attributes and actions originally grouped themselves in the mind, imply a self-suppression that is impracticable.

Nevertheless, we must here do our best to conceive the surrounding world as it appeared to the primitive man, that we may be able

[1] From author's advance sheets of the "Principles of Sociology," Part II., chapter viii. "Primitive Ideas."

the better to interpret deductively the evidence available for induction. And, though we are incapable of reaching the conception by a direct process, we may make some approach to it by an indirect process. Guided by the doctrine of evolution in general, and by the more special doctrine of mental evolution, we may help ourselves to delineate primitive ideas in some of their leading traits. Having observed *a priori* what must be the characters of those ideas, we shall be as far as possible prepared to realize them in imagination, and then to discern them as actually existing.

We must set out with the postulate that primitive ideas are natural, and, under the conditions in which they occur, rational. In early life we have been taught that human nature is everywhere the same. Led thus to contemplate the beliefs of savages as beliefs entertained by minds like our own, we marvel at their strangeness, and ascribe perversity to those who hold them. Casting aside this error, we must substitute for it the truth that the laws of thought are everywhere the same, and that, given the data as known to him, the inference drawn by the primitive man is the reasonable inference.

In the sky, clear a few moments ago, the savage sees a fragment of cloud which grows while he gazes. At another time, watching one of these moving masses, he observes shreds of it drift away and vanish; and presently the whole disappears. What thought results in him? He knows nothing about precipitation and dissolution of vapor, nor has there been any one to stop his inquiry by the reply, "It is only a cloud." The essential fact forced on his attention is that something he could not before see has become visible, and something just now visible has vanished. The whence, and the where, and the why, he cannot tell; but there is the fact.

In this same space above him occur other changes. As day declines, bright points here and there show themselves, becoming clearer and more numerous as darkness increases, and then at dawn they fade gradually, until not one is left. Differing from clouds utterly in size, form, color, etc., differing also as continually reappearing in something like the same places, in the same relative positions, and in moving but very slowly always in the same way, they are yet like them in becoming now visible and now invisible. That feeble lights may be wholly obscured by a bright light, and that the stars are shining during the day though he does not see them, are facts beyond the imagination of the savage. The truth, as he perceives it, is that these existences now show themselves and now are hidden.

Differing greatly from clouds and stars in their behavior as the sun and moon do, they show, in common with them, this same alternation of visibility with invisibility. The sun rises on the other side of the mountains; from time to time going behind a cloud, presently comes out again; and at length hides below the level of the sea. The

moon, besides doing the like, first increases slowly night after night, and then wanes, by-and-by reappearing as a thin bright streak, with the rest of her disk so faintly perceptible as to seem only half existing.

Added to these commonest and most regular occultations and manifestations, are various others, even more striking—comets, meteors, and the aurora with its arch and pulsating streams; flashes of lightning, rainbows, halos. Differing from the rest and from one another as these do, they similarly appear and disappear. So that by a being absolutely ignorant, but able to remember, and to group the things he remembers, the heavens must be regarded as a scene of arrivals and departures of many kinds of existences; some gradual, some sudden, but alike in this, that it is impossible to say whence the existences come or whither they go.

Not the sky only, but also the earth's surface, supplies various instances of these disappearances of things which have unaccountably appeared. Now the savage sees little pools of water formed by the rain-drops coming from a source he cannot reach; and now, in a few hours, the gathered liquid has made itself invisible. Here, again, is a fog; perhaps lying isolated in the hollows, perhaps enwrapping every thing, which came a while since and presently goes without leaving a trace of its whereabouts. Afar off is perceived water—obviously a great lake; but on approaching it the seeming lake recedes, and cannot be found. In the desert, what we know as sand-whirlwinds, and on the sea what we know as water-spouts, are to the primitive man moving things which appear and then vanish. Looking out over the ocean, he recognizes an island known to be a long way off, and commonly invisible, but which has now risen out of the water; and to-morrow, just above the horizon, he observes an inverted figure of a boat, perhaps by itself, or perhaps joined to an erect figure above. In one place he sometimes perceives land-objects on the surface of the sea, or in the air over it—*a fata morgana;* and in another, over against him on the mist, there occasionally comes into view a gigantic duplicate of himself—"a Brocken spectre." These occurrences, some familiar and some unfamiliar, repeat the same experience—show transitions between the visible and the invisible.

Once more, let us ask what must be the original conception of wind. Consider the facts apart from hypothesis, and the implication which every breeze or gust carries with it is that of a power neither visible nor tangible. Nothing in early experiences yields the idea of air, as we are now familiar with it; and, indeed, probably most can recall the difficulty they once had in thinking of the surrounding medium as a material substance. The primitive man cannot regard it as a something which acts as do the things he sees and handles. Into this seemingly-empty space around, there from time to time comes an invisible agent which bends the trees, drives along the leaves, disturbs the water, and which he feels moving his hair, fanning his cheek, and

now and then pushing his body with a force he has some difficulty in overcoming. What may be the nature of this agent there is nothing to tell him; but one thing is irresistibly thrust on his consciousness —that sounds can be made, things about him can be moved, and he himself can be buffeted, by an existence he can neither grasp nor see.

What primitive ideas arise out of these experiences derived from the inorganic world? In the absence of hypothesis (which is foreign to thought in its earliest stages), what mental association do these multitudinous occurrences, some at long intervals, some daily, some hourly, some from minute to minute, tend to establish? They present, under many forms, the relation between a perceptible and an imperceptible mode of existence. In what way does the savage think of this relation? He cannot think of it in terms of dissipation into vapor and condensation from it, nor in terms of optical relations producing illusions, nor in any terms of physical science. How, then, does he formulate it? A clew to the answer will be furnished by recalling certain remarks of young children. When an image from the magic lantern, thrown on a screen, suddenly disappears on withdrawal of the slide, or when the reflection from a looking-glass, cast for a child's amusement on the wall or ceiling, is made to vanish by changing the attitude of the glass, the child asks, "Where is it gone to?" The notion arising in its mind is, not that this something no longer seen has become non-existent, but that it has become non-apparent; and it is led to think this by daily observing persons disappear behind adjacent objects, by seeing things put away out of sight, and by now and again finding a toy that had been hidden or lost. Similarly, the primitive idea is, that these various existences now manifest themselves and now conceal themselves. As the animal which he has wounded hides itself in the brushwood, and, if it cannot be found, is supposed by the savage to have escaped in some incomprehensible way, but to be still existing, so, in the absence of accumulated and organized knowledge, the implication of all these experiences is that many of the things above and around pass often from visibility to invisibility, and conversely. Bearing in mind how the actions of wind prove that there is an invisible form of existence which manifests power, we shall see this belief to be plausible.

It remains only to be pointed out that along with this conception of a visible condition and an invisible condition, which each of these many things has, there comes the conception of duality. Each of them is in a sense double, since it has these two complementary modes of being.

Significant facts of another order, from time to time disclosed, may next be noted—facts irresistibly impressing the primitive man with the belief that things are transmutable from one kind of substance to another. I refer to the facts forced on his attention by embedded remains of animals and plants.

While gathering food on the sea-shore, he finds, protruding from a rock, a shell which, if not of the same shape as the shells he picks up, is so similar that he naturally classes it with them. But, instead of being loose, it is part of a solid block; and, on breaking it off, he finds its inside as hard as its matrix. Here, then, are two kindred forms, one of which consists of shell and flesh, and the other of shell and stone. Near at hand, in the mass of clay *débris* detached from the adjacent cliff, he picks up a fossile ammonite. Perhaps, like the *Gryphœa* just examined, it has a shelly coating with a stony inside. Perhaps, as happens with some liassic ammonites of which the shell has been dissolved away, leaving the masses of indurated clay that filled its chambers locked loosely together, it suggests a series of articulated vertebræ coiled up; or, as with other liassic ammonites of which the shell has been replaced by iron pyrites, it has a glistening appearance like that of a snake's skin. As such fossils are sometimes called "snake-stones," and are in Ireland supposed to be the serpents St. Patrick banished, we cannot wonder if the uncritical savage, classing this object with those it most resembles, thinks it a transmuted snake—once flesh and now stone. In another place, where a gully has been cut through sandstone by a stream, he observes on the surface of a slab the outline of a fish, and, looking closely, sees scales and the traces of fins; and elsewhere, similarly embedded in rock, he finds skulls and bones not unlike those of the animals he kills for food; some of them, indeed, not unlike those of men.

Still more striking are the transmutations of plants occasionally discovered. I do not refer so much to the prints of leaves in shale, and the fossil stems found in strata accompanying coal; I refer, more especially, to the silicified trees here and there met with. Retaining, not their general forms only but their minute structures, so that the annual growths are marked by rings of color such as mark them in living stems, these yield the savage clear evidence of transmutation. With all our knowledge it remains difficult to understand how silica can so replace the components of the wood as to preserve the appearance thus perfectly; and for the primitive man, knowing nothing of molecular action and unable to conceive a process of substitution, there is no possible thought but that the wood is changed into stone.

Thus, if we ignore those conceptions of physical causation which have arisen only as experiences have been slowly organized during civilization, we shall see that in their absence there would be nothing to prevent us from putting on these facts the interpretations which the primitive man puts on them. Looking at the evidence through his eyes, we find his belief, that things change from one kind of substance to another, to be the inevitable belief.

And here let us not omit to note that along with the notion of transmutation is involved the notion of duality. These things have obviously two states of existence.

Much evidence forces on the primitive man the notion that things can change their forms as well as their substances. Did we not thoughtlessly assume that truths which culture has made obvious to us are naturally obvious, we should see that an unlimited belief in metamorphosis is one which the savage cannot avoid. From early childhood we hear remarks implying that certain transformations which living things undergo are matters of course, while other transformations are impossible. This distinction we suppose to have been manifest at the outset. But, at the outset, the observed metamorphoses suggest that any metamorphosis may occur.

Consider the immense contrast in form as in substance between the seed and the plant. Look at this nut with hard brown shell and white kernel, and ask what basis there is for the expectation that from it will presently come a soft shoot and green leaves. When young we are told that the one *grows* into the other; and, the blank form of explanation being thus filled up, we cease to wonder and inquire. Yet, it needs but to consider what thought would have arisen had there been no one to give this mere verbal solution, to see that the thought would have been—transformation. Apart from hypothesis, the bare fact is that a thing having one size, shape, and color, becomes a thing having an utterly different size, shape, and color.

Similarly with the eggs of birds. But a few days since this nest contained four or five rounded, smooth, speckled bodies; and now in place of them are as many chicks gaping for food. We are brought up to the idea that the eggs have been *hatched;* and with this semblance of interpretation we are content. This extreme change in visible and tangible characters being recognized as one constantly occurring in the order of Nature, is therefore regarded as not remarkable. But to a mind occupied by no generalized experiences of its own or of others, there would seem nothing more strange in the production of chicks from nuts than in the production of chicks from eggs: a metamorphosis of the kind we think impossible would stand on the same footing as one which familiarity has made us think natural. Indeed, on remembering that there still survives, or till lately survived, the popular belief that barnacle-geese arise from barnacles—on learning that, even in the early transactions of the Royal Society, there is a paper describing a barnacle as showing faint traces of the young bird it is about to produce—it will be seen that only by advanced science has there been discriminated the natural organic transformations, from transformations which to ignorance seem just as likely.

The insect-world yields instances of metamorphoses even more misleading. To a branch which shades the opening of his wigwam, the savage saw, a few days ago, a caterpillar hanging with its head downward. Now in the same place hangs a differently formed and colored thing—a chrysalis. In a week or two after there comes out a butterfly: leaving a thin, empty case. These insect-metamorphoses,

as we call them, which we now interpret as processes of evolution presenting certain definitely-marked stages, are, in the eyes of the primitive man, metamorphoses in the original sense. He accepts them as actual changes of one thing into another thing utterly different.

How readily the savage confounds these metamorphoses which really occur with metamorphoses apparently like them but impossible, we shall perceive on considering a few cases of mimicry by insects, and the conclusions they lead to. Many caterpillars, beetles, moths, butterflies, simulate the objects by which they are commonly surrounded. The *Onychocerus scorpio* is so exactly like, "in color and rugosity," to a piece of the bark of the particular tree it frequents, "that until it moves it is absolutely invisible:" thus raising the idea that a piece of the bark itself has become alive. Another beetle, *Onthophilus sulcatus*, is "like the seed of an umbelliferous plant;" another "undistinguishable by the eye from the dung of caterpillars;" some of the *Cassidæ* "resemble glittering dew-drops upon the leaves;" and there is a weevil so colored and formed that, on rolling itself up, it "becomes a mere oval brownish lump, which it is hopeless to look for among the similarly-colored little stones and earth pellets among which it lies motionless," and out of which it emerges after its fright, as though a pebble had become animated. To these examples given by Mr. Wallace, may be added that of the "walking-stick insects," so called "from their singular resemblance to twigs and branches."

"Some of these are a foot long and as thick as one's finger, and their whole coloring, form, rugosity, and the arrangement of the head, legs, and antennæ, are such as to render them absolutely identical in appearace with dead sticks. They hang loosely about shrubs in the forest, and have the extraordinary habit of stretching out their legs unsymmetrically, so as to render the deception more complete."

What wonderful resemblances exist, and what illusions they may lead to, will be fully perceived by those who have seen, in Mr. Wallace's collection of butterflies, the Indian genus *Kallima*, placed amid the objects it simulates. Habitually settling on branches bearing dead leaves, and closing its wings, it then resembles a dead leaf, not only in general shape, color, markings, but in so seating itself that the processes of the lower wings unite to form the representation of a foot-stalk. When it takes flight, the impression produced is that one of the leaves has changed into a butterfly. This impression is greatly strengthened when the creature is caught. On the under side of the closed wings is still clearly marked the midrib, running right across them from foot-stalk to apex; and here, too, are lateral veins. Nay, this is not all. Mr. Wallace says:

"We find representations of leaves in every stage of decay, variously blotched and mildewed and pierced with holes, and in many cases irregularly covered with powdery black dots gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves that it is

impossible to avoid thinking at first sight that the butterflies themselves have been attacked by real fungi."

On recalling the fact that, a few generations ago, all civilized people believed, as many civilized people believe still, that decaying meat is itself transformed into maggots, on being reminded that among our peasantry, at the present time, the thread-like aquatic worm *Gordius* is said to be horse-hair that has fallen into the water and become living, we shall see it to be inevitable that these extreme resemblances should suggest the notion of actual metamorphoses. That this notion, so suggested, becomes a belief, is a proved fact. In Java and neighboring regions inhabited by it, that marvelous insect, "the walking leaf," is positively asserted to be a leaf that has become animated. What else should it be? In the absence of that explanation of mimicry so happily hit upon by Mr. Bates, no natural origin for such wonderful likenesses between things wholly unallied can be imagined. And, while there is no generalized knowledge, there is nothing to prevent acceptance of these apparent transformations as real transformations; indeed, apparent and real are not distinguished until criticism and skepticism have made some progress.

Once established, the belief in transformation extends itself without resistance to other classes of things. Between an egg and a young bird, there is a far greater contrast in appearance and structure than between one mammal and another. The tadpole, with a tail and no limbs, differs from a young frog with four limbs and no tail, more than a man differs from a hyena; for both of these have four limbs, and both laugh. Evidently, then, the natural metamorphoses so abundant throughout Nature, joined with these apparent metamorphoses which the primitive man inevitably confounds with them, originate the conception of metamorphoses in general, which rises into an explanation everywhere employed without check.

Here, again, we have to note that, while initiating and fostering the notion that things of all kinds may suddenly change their forms, the experiences of transformation confirm the notion of duality. Each object is not only what it seems, but is potentially something else.

What is a shadow? Familiar as mature life has made us with shadows, and almost automatic as has become the interpretation of them in terms of physical causation, we do not ask how they look to the absolutely ignorant.

Those, from whose minds the thoughts of childhood have not wholly vanished, will remember the interest they once felt in watching their shadows—moving legs and arms and fingers, and observing how corresponding parts of the shadows moved. By a child a shadow is thought of as an entity. I do not assert this without evidence. A memorandum made in 1858, in elucidation of the ideas described in the just-published book of Williams on the Feejeeans, concerns a little

girl of some seven, who did not know what a shadow was, and to whom I could give no conception of its true nature.

On ignoring acquired ideas, we shall see this difficulty to be quite natural. A thing having outlines, and differing from surrounding things in color, and especially a thing which moves, is, in other cases, a reality. Why is not this a reality? The conception of it, merely a negation of light, is a conception not to be framed until after the behavior of light is in some degree understood. It is true that the uncultured among ourselves, without clearly formulating the truth that light, proceeding in straight lines, necessarily leaves unlighted spaces behind opaque objects, nevertheless come to regard a shadow as naturally attending an object exposed to light, and as not being any thing real. But this is one of the countless cases in which inquiry is set at rest by a verbal explanation. "It's only a shadow," is the answer given in early days; and this answer, repeatedly given, deadens wonder and stops further thought.

But the primitive man, with no one to answer his questions, and without ideas of physical causation, necessarily concludes a shadow to be an actual existence, which belongs in some way to the person casting it. He simply accepts the facts. Whenever the sun or moon is visible, he sees this attendant thing which rudely resembles him in shape, which moves when he moves, which now goes before him, now keeps by his side, now follows him, which lengthens and shortens as the ground inclines this way or that, and which distorts itself in strange ways as he passes by irregular surfaces. True he cannot see it in cloudy weather; but, in the absence of a physical interpretation, this simply proves that his attendant something comes out only on bright days and bright nights. It is true, also, that such resemblance as his shadow bears to him, and its approximate separateness from him, are shown only when he stands up: on crouching, it becomes indefinitely formed; and as he lies down it seems to disappear and partially merge into him. But this observation confirms his impression of its reality. This greater or less separateness of his own shadow reminds him of cases where a shadow is quite separate. When watching a fish in the water on a fine day, he sees a dark, fish-shaped patch on the bottom at a considerable distance from the fish, but nevertheless following it hither and thither. Lifting up his eyes, he observes dark patches moving along the mountain-sides—patches which, whether traced or not to the clouds that cast them, are seen to be widely disconnected from objects. These facts show him that shadows, often so closely joined with their objects as to be hardly distinguishable from them, may become distinct and remote.

Thus, by minds beginning to generalize, shadows must be conceived as existences appended to, but capable of separation from, material things. And that they are so conceived is abundantly proved. We find it stated by Bastian of the Benin negroes, that they regard

men's shadows as their souls; and he also says of the Wanika that they are afraid of their own shadows: possibly thinking, as some other negroes do, that their shadows watch all their actions, and bear witness against them. Among the Greenlanders, according to Crantz, a man's shadow is one of his two souls—the one which goes away from his body at night. Among the Feejeeans, too, the shadow is called "the dark spirit," as distinguished from another which each man possesses. And the community of meaning, hereafter to be noted more fully, which various unallied languages betray between shade and spirit, shows us the same thing.

These illustrations of the truth that a shadow is originally regarded as an appended entity suggest more than I here wish to show. The ideas of the uncivilized, as we now find them, have developed from their first vague forms into forms having more coherence and definiteness. We must neglect the special characters of these ideas, and consider only that most general character with which they began. This proves to be the character we inferred above. Shadows are realities which, always intangible and often invisible, nevertheless severally belong to their visible and tangible correlatives; and the facts they present furnish further materials both for the notion of apparent and unapparent states, and for the notion of a duality in things.

Other phenomena, in some respects allied, yield these notions still more materials. I refer to reflections.

If the rude resemblance in outlines and movements which a shadow bears to the person casting it raises the idea of a second entity, much more must the exact resemblance of a reflection do this. Repeating all the details of form, of light and shade, of color, and mimicking even the grimaces of the original, this image cannot at first be interpreted otherwise than as an existence. Only by experiment is it ascertained that to the visual impressions there are not, in this case, those corresponding tactual impressions yielded by most other things. What results? Simply the notion of an existence which can be seen but not felt. Optical interpretation is impossible. That the image is formed by reflected rays, cannot be conceived while physical knowledge does not exist; and, in the absence of authoritative statement that the reflection is a mere appearance, it is inevitably taken for a reality—a reality in some way belonging to the person whose traits it simulates and whose actions it mocks.

Moreover, these duplicates seen in the water yield to the primitive man obvious verifications of certain other beliefs which surrounding things suggest. Deep down in the clear pool, are there not clouds like those he sees above? The clouds above appear and disappear. Has not the existence of these clouds below something to do with it? At night, again, seeming as though far underneath the surface of the water, are stars as bright as those overhead. Are there, then, two

places for the stars? and did those which disappeared during the day go below where the rest are? Once more, overhanging the pool is this dead tree, from which he breaks off branches for firewood. Is there not an image of it too? and the branch which he burns and which vanishes into nothing in burning—is there not some connection between its invisible state and that image of it in the water which he could not touch, any more than he can now touch the consumed branch?

That reflections thus generate a belief—confused and inconsistent it may be, but still a belief—that each individual has a duplicate, usually unseen, but which may be seen on going to the water-side and looking in, is not an *a priori* inference only; there are facts verifying it. According to Williams, some Feejeeans "speak of man as having two spirits. His shadow is called 'the dark spirit,' which, they say, goes to Hades. The other is his likeness reflected in water or a looking-glass, and is supposed to stay near the place in which a man dies." This belief in two spirits is, indeed, the most consistent one. For are not a man's shadow and his reflection separate? and are they not coexistent with one another and with himself? Can he not, standing at the water-side, observe that the reflection in the water and the shadow on the shore, simultaneously move as he moves? Clearly, while both belong to him, the two are independent of him and of one another; for both may be absent together, and either may be present in the absence of the other.

Early theories about this duplicate are now beside the question, and must be ignored. We are concerned only with the fact that it is thought of as real. To the primitive mind, making first steps in the interpretation of the surrounding world, here is revealed another class of facts confirming the notion that existences have their visible and invisible states, and strengthening the implication of a duality in each existence.

Let any one ask himself what would be his thought if, in a state of childlike ignorance, he were to pass some spot and to hear repeated a shout which he uttered. Would he not inevitably conclude that the answering shout came from another person? Succeeding shouts severally repeated with words and tones like his own, yet without visible source, would rouse the idea that this person was mocking him, and at the same time concealing himself. A futile search in the wood or under the cliff would end in the conviction that the hiding person was very cunning: especially when joined to the fact that here, in the spot whence the answer before came, no answer was now given—obviously because it would disclose the mocker's whereabouts. If at this same place, on subsequent occasions, this responsive shout from a source eluding search always came to any passer-by who called out, the resulting thought would be that in this place there dwelt one of these

invisible forms—a man who had passed into an invisible state, or who could become invisible when sought.

Nothing approaching to the physical explanation of an echo can be framed by the uncivilized man. What does he know about the reflection of sound-waves?—what, indeed, is known about the reflection of sound-waves by the mass of our own people? Were it not that the spread of knowledge has modified the mode of thought throughout all classes, producing everywhere a readiness to accept what we call natural interpretations, and to assume that there are natural interpretations to occurrences not comprehended, there would even now be an explanation of echoes as caused by unseen beings.

That to the primitive mind they thus present themselves is shown by facts. Southey, writing of the Abipones, says that "what became of the Lokal" (spirit of the dead) "they knew not, but they fear it, and believe that the echo was its voice." Concerning the Indians of Cumana (Central America), Herrera tells us that they "believed the soul to be immortal, that it did eat and drink in a plain where it resided, and that the echo was its answer to him that spoke or called." And, narrating his voyage down the Niger, Lander says that "from time to time, as we came to a turn in the creek, the captain of the canoe halloed to the fetich, and, where an echo was returned, half a glass of rum and a piece of yam and fish were thrown into the water. When asked why, he said, 'Did you not hear the fetich?'"

Here, as before, I must ask the reader to ignore these special interpretations, acceptance of which forestalls the argument. Attention is now drawn to this evidence simply as confirming the inference that, in the absence of physical explanation, an echo is conceived as the voice of some one who avoids being seen. So that once more we have duality implied—of an invisible as well as a visible state.

To a mind unfurnished with any ideas save those of its own gathering, surrounding Nature thus presents multitudinous cases of seemingly-arbitrary change—now slight and slow, now gradual and great, now sudden and extreme. In the sky and on the earth, things make their appearance and disappear; and there is nothing to show why they do so. Here on the surface and there deeply embedded in the ground are things that have been transmuted in substance—changed from flesh to stone, from wood to flint. Living bodies on all sides exemplify metamorphosis in ways marvelous enough to the instructed, and to the primitive man quite incomprehensible. And this protean character which so many things around him exhibit, and which familiarize him with the notion that there are two or more interchangeable states of existence, is again impressed on him by such phenomena as shadows, reflections, and echoes.

Did we not thoughtlessly accept as innate the conceptions slowly elaborated during civilization and acquired insensibly during our early days, we should at once see that these ideas which the primitive man

forms are inevitably formed. The laws of mental association necessitate these primitive notions of transmutation, of metamorphosis, of duality; and, until experiences have been systematized, no limits or restraints are known. With the eyes of developed knowledge we look at the snow as a particular form of crystallized water, and at hail as drops of rain which congealed as they fell. When these become fluid we say they have thawed—thinking of the change as a physical effect of heat; and, similarly, when the hoar-frost fringing the sprays turns into hanging drops, or when the surface of the pool solidifies and again liquefies. But, looked at with the eyes of absolute ignorance, these are transmutations of substance—passings from one kind of existence into another kind of existence. And in like ways are necessarily conceived all the changes above enumerated.

Let us now ask what happens in the primitive mind when there has been accumulated this heterogeneous assemblage of crude ideas, having, amid their differences, certain resemblances. In conformity with the law of evolution, every aggregate tends to integrate, and to differentiate while it integrates. The aggregate of primitive ideas must do this. After what manner will it do it? At the outset, these multitudinous vague notions form a loose mass without order. They slowly segregate, like cohering with like, and so forming indefinitely-marked groups. When these groups begin to form a consolidated whole, constituting a general conception of the way in which things at large go on, they must do it in the same way: such coherence of the groups as arises must be due to some likeness among the members of all the groups. We have seen that there is such a likeness—this common trait of duality joined with this aptitude for passing from one mode of existence to another.

Integration must commence by the recognition of some conspicuous typical case. It is a truth perpetually illustrated, that accumulated facts lying in disorder begin to assume some order if an hypothesis is thrown among them. When into a chaos of detached observations is introduced an observation akin to them in which a causal relation is discernible, it forthwith commences assimilating to itself from this heap of observations those which are congruous, and tends even to coerce into union those of which the congruity is not manifest. One may say that as the protoplasm forming an unfertilized germ remains inert until the matter of a sperm-cell is joined with it, but begins to organize when this addition is made, so a loose aggregate of observations continues unsystematized in the absence of an hypothesis, but under the stimulus of an hypothesis undergoes changes bringing about a coherent systematic doctrine. What particular example, then, of this prevalent duality plays the part of an organizing principle to the aggregate of primitive ideas? We must not look for an hypothesis properly so called: an hypothesis is an implement of inquiry not to be framed by the primitive mind. We must look for some experience in

which this duality is forcibly thrust on the attention. As a consciously-held hypothesis is habitually based on some obtrusive instance of a relation, which other instances are suspected to be like, so the particular primitive notion which is to serve as an unconscious hypothesis, setting up organization in this aggregate of primitive notions, must be one conspicuously exemplifying their common trait.

First identifying this typical notion, we shall afterward have to enter on a survey of the general conceptions which result. It will be needful to pursue various lines of inquiry and exposition not manifestly relevant to our subject; and it will also be needful to consider the meaning of much evidence furnished by men who have advanced beyond the savage state. But this discursive treatment is unavoidable. Until we can figure to ourselves with approximate truth the primitive system of thought, we cannot fully understand primitive conduct; and, rightly to conceive the primitive system of thought, we must compare the systems found in many societies, helping ourselves, by observing its developed forms, to verify our conclusions respecting its undeveloped form.

CHAMELEONS—THEIR HABITS AND COLOR-CHANGES.

By J. FITZGERALD, A. M.

IN consequence of the incredible stories anciently told of the chameleon, one is hardly disposed to regard that animal as a reality; it appears to find its proper place in mythology rather than in natural history—among fabled dragons, centaurs, and griffins, rather than among the actualities of the animal kingdom. The chameleon, however, has a real existence; and, after fiction and fable are brushed aside, a very curious creature indeed remains. It belongs to the Saurian order (lizards). The genus *Chamæleo* embraces about twenty species, none of them American. With one exception, the *common chameleon*, which is naturalized in Southern Spain and in Sicily, these animals are found only in the warmer parts of Africa and Asia. The chameleon is from ten to fifteen inches in length, whereof one-half is represented by the prehensile tail. The body is roughly pyramidal in shape; the skin is covered with papillous elevations instead of scales, and these, in some of the species, assume the shape of spiny processes along the ridge of the back and the median line of the chest and belly. The toes, five in number, are divided into two opposable sets of two and three, the toes of each set being webbed down to the claws, which are long and sharp. The head is angular, rising into a pyramidal occiput. The eyeball is very large, protruding, covered with a single lid, which has a minute aperture in the centre

for the very small pupil. There is no external ear. The tongue is extensible to the length of half the total length of the animal, that is, from five to seven inches. The lungs are large, and connect with air-cells underlying the skin. The neck is so short as to prevent the head being turned from side to side. Though the chameleon is arboreal in

CHAMELEON—TONGUE OF CHAMELEON.

its habits, it is very slow in its movements. It is unprovided with any weapons of defense against its enemies. The female lays about thirty eggs, which are deposited in a hollow in the ground, and covered with loose earth.

The immobility of the chameleon distinguishes it markedly from the rest of the lizard tribe, which are generally active and quick in

their movements. Alfred Brehm, who received as a present from the African explorer, Schweinfurth, a number of these animals, states that the chameleon never moves at all except from necessity; it will remain in one position on a branch or twig for hours at a time, firmly grasping with tail and paws the object on which it is perched. The eyes, on the contrary, are nearly always in motion. The chameleons sent to Brehm reached their destination in indifferent condition, the skin dry and flabby, and the animals utterly apathetic. Water having been showered upon them in fine spray, they began to recover, and to lick the drops from one another's backs; their skin assumed a better color, and soon they were clambering up and down the branches which stood in their cage, and even engaging in combat. In their battles they use their teeth, but without doing serious injury; and they have a curious way of solemnly lashing one another with their tails. But such activity as this is exceptional in the chameleon: it is to be seen especially in the pairing season. When preying on winged insects, the chameleon is seen occasionally to protrude the knobbed end of his tongue, and in an instant that member is shot forth and again retracted, bearing the prey into the captor's mouth. The extremity of the tongue exudes a sticky substance on which the prey is caught. When flies and other winged insects are not to be had, the chameleon's swivel-eyes scan the trunk of the tree, and the branches above, below, and on all sides around, to see if any creeping thing may be caught. If any such creature is approaching the spot where the chameleon is lying, he waits till it comes within striking distance, and then "discharges" his tongue at it. But, if the creature is traveling away from him, he pursues, though with grave deliberation. If the prey comes very near to his muzzle, the chameleon retreats a little, to increase the distance, and then darts out his tongue. In performing this act, the chameleon displays very great activity; otherwise, all his movements are the reverse of precipitate. Thus, if he would change from his normal position of absolute quietude—his belly resting on an horizontal branch, which he grasps as firmly as he can with all five hands (for his tail is a fifth hand)—he first advances one of the fore-paws one step; then the tail is relaxed, advanced an equal distance, and again coiled tight; next the other feet are advanced a step, one after another; and so on. It is not easy to recognize the propriety of the name *little lion* (*chamælon*) given to this reptilian tardigrade by the ancient Greeks. And the animal is as harmless as it is slow of movement, though the ancients supposed that in the dog-days it assumes some of the lion's ferocity.

The large, projecting eyeballs of the chameleon are capable of a great variety of movements; and, what is very curious, each of them may, and usually does, act independently of the other. This circumstance compensates for the fixedness of the head, enabling the animal to direct its glances on all sides, without the necessity of calling into play any muscles save those of the eyeball. Still, when about to strike,

the chameleon brings both of its eyes to bear upon the object. "Notwithstanding," says Weissenbaum, "the strictly symmetrical construction of the chameleon as to its two halves, the eyes move independently of each other, and convey different impressions to the different centres of perception: the consequence is that, when the animal is agitated, its movements appear like those of two animals glued together. Each half wishes to move its own way, and there is no concert of action. The chameleon, therefore, is not able to swim like other animals; it is so frightened when put into water that the faculty of concentration is lost, and it tumbles about as if in a state of intoxication. Nay, more, the chameleon may be asleep on one side and awake on the other."

The chameleon is often seen to inhale air, gulp after gulp, with great avidity, thus inflating its body enormously, even to the feet and tail. As has been already stated, the animal's lungs are very large—so large, indeed, that it was supposed by Pliny (who simply transcribes the accounts given by Greek authors) that the lungs almost filled the entire cavity of the body; these lungs connect with the air-cells beneath the skin. By taking air into the lungs, whence it passes into the air-cells, the chameleon is able to inflate itself to as much as twice its ordinary size; and often it remains so inflated for a long time, now slightly collapsing, again swelling out, till the skin becomes as tense as the head of a drum. No doubt it was this power of self-inflation which led the ancients to suppose that, "alone among animals, the chameleon neither eats nor drinks, its only sustenance being air." —(*Pliny.*)

But the color-changes of the chameleon form perhaps the most interesting phenomenon connected with this animal. We need not repeat the fabulous stories told about these color-changes: the facts which can be strictly verified by direct observation are wonderful enough without the adornments of imagination. These changes of color range from whity-yellow, through yellow, bright and dark green, to dull black; and these diversities of coloration may affect the entire surface of the animal, or one or other of its sides, or may appear only in spots. When the chameleon is asleep, and not exposed to the direct rays of the sun, its color is a whity-yellow; when basking in the sun, it is a dingy black or dusky brown. On being aroused from sleep, the side which is first awakened assumes a darker shade. There is reason for believing that sunlight, apart from the warmth which accompanies it, is very grateful to the chameleon, and, in response to this stimulus, he at once begins his play of color. M. Paul Bert, a French *savant*, whose name is familiar to the readers of THE POPULAR SCIENCE MONTHLY, has for some time been engaged in studying the anatomy and mechanism of these phenomena. His researches are not yet completed, but we may state some of the facts which he has established.

In the skin of the chameleon he finds a close net-work of minute ducts, connecting with pigment-vesicles situated on its under surface. When the coloring-liquid is all retained in these vesicles, the animal's skin appears yellowish, that being the color of the semi-transparent epidermis. When the liquid is injected into the ducts, the color of the animal changes, the tint depending on the degree of tension in the ducts. If a nerve be cut, the region of the chameleon's body to which that nerve was distributed becomes at once a deep black, and no more color-changes occur over that area. If a piece of the skin be placed under a microscope, it will appear black. Pass a current of electricity through it, and there will be seen white vacuoles, which coalesce into irregularly-shaped masses, and these in turn break up into minute vacuoles again, leaving the field of a greenish color. Stop the current, and the reverse order of phenomena appears. M. Bert finds that the effect of curare on the chameleon is to give it a very dark color, while chloroform, on the contrary, lightens the tint; but when given in quantity sufficient to destroy the animal's life, chloroform darkens the color. Bert is disposed to believe that the chameleon possesses a special set of "color-nerves" distinct from the motor and sensory systems, and that these nerves are under the control of the will.

THE ENGLISH OBSERVATORIES.

TRANSLATED FROM THE FRENCH, BY EMMA M. CONVERSE.

THE English Astronomer Royal has in his possession a very curious collection of papers, including letters that have been addressed to him by persons of every condition, in which they ask his price for casting a horoscope. In spite of such simplicity, England is one of the countries where the taste for practical astronomy is very widely diffused, and also the one where the greatest number of public and private observatories is found. Establishments of the last category abound in the United Kingdom, and attest by their number and importance the popularity of the most sublime of the sciences. There are at the present time forty observatories in the British Isles, and fifteen in the English colonies; this is a quarter of the total number that is found in the whole globe, for there are in Europe something like a hundred and twenty establishments meriting this name, and about two hundred in the entire world.

The Royal Observatory of Greenwich takes the lead, for its past labors as well as for its present position, over the other establishments of the same kind possessed by the English. It was founded in 1675, three years after the Observatory of Paris. Charles II. chose a locality for the edifice on a hill commanding the Thames and the passage

of vessels, so that his astronomers would be able, by the study of the movements of the heavens, to direct the distant courses of ships over the surface of the sea. The interest of the marine was in reality the controlling motive that determined the foundation of this establishment. The ordinance of 1673 decrees that "the astronomer royal shall devote his time to rectifying the tables of celestial bodies and the positions of the fixed stars in order to obtain the means of finding the longitude at sea." To indicate in a precise manner the position of the stars, to predict with certainty the course of the moon in relation to these fixed data, is the great work reserved for sedentary astronomy in the progressive improvement of the art of navigation. The heavens constitute, as it were, a revolving dial-plate, on which the moon, making her way from star to star, marks for the navigator the absolute time, the time at Greenwich, while the height of the sun above the horizon furnishes the time of the place where he chances to be, and it is by comparison that he finds out his longitude, that is, the meridian under which he is passing. The regular and long-continued observation of the fixed stars, sun and moon, was then traditional in this illustrious establishment of Greenwich, which has had for directors such astronomers as Flamsteed, Halley, Bradley, Maskelyne, Pond, and George-Biddell Airy, who has been director since 1835. It is there that the first foundation of modern astronomy has been laid, that is to say, the astronomy of precision. Far from seeking an easily-obtained glory in the discoveries, more brilliant than really important, that strike the mind of the crowd, the Greenwich astronomers have invariably applied themselves to the laborious investigation of those minutiæ upon which the edifice of science reposes, and where often the trace of great unknown laws is revealed.

Flamsteed, the first director, made all his observations by the aid of a sextant and a mural arc, which were his own private property; the first reports were printed without his consent, and were so imperfect that he burned all of the first edition that had not been distributed, in order to have a new one made under his own inspection, and at his own expense. His successor, Halley, found the building stripped of all the apparatus; the heirs of Flamsteed had carried away every thing. This was perhaps a piece of good fortune for science, as Halley was obliged to procure new instruments, and in 1721 he caused a transit instrument to be constructed. This became the prime mover in astronomical researches, and the observations that Bradley made with its aid are the points of departure for our catalogues of the stars, for they permit us to appreciate with certainty the changes that have been brought about by time in the relative situation of the fixed stars, and consequently to reduce the observations of each day to a given epoch.

When Bradley was called, in 1742, to the direction of the Greenwich Observatory, he was already celebrated by discoveries of the first order,

and known as an accomplished observer. It has always been thus; the scientific men who have been successively placed at the head of this establishment were, at the time of their nomination, perfectly familiar with the routine of their profession. They have all in like manner devoted themselves with special zeal to the improvement of instruments, and to the perfection of methods; the result has been that happy stability in principles, that continuity in labors, which is the first condition for the success of researches destined to reveal to us the slow variations that are going on in the system of the world.

Greenwich is so much the more free to concentrate all its efforts upon the astronomy of precision, as numerous observatories around it, erected by opulent universities, or due to the enlightened initiative of some rich proprietors and the great merchants of the city, share the labors that the central establishment leaves out of its programme. Oxford possesses an important observatory, founded in 1771, by the aid of a legacy of Dr. Radcliffe, now under the direction of the Rev. Robert Main, and the university has decided to found a second one. Cambridge has the Trinity Observatory, that Mr. Airy directed from 1827 to 1835, and which is now intrusted to Mr. Adams; the University of Durham possesses also a very well-organized observatory, founded by the city thirty years since.

The observatory of Liverpool was created specially for the study of marine chronometers. There, the numerous ships that enter the port of the Mersey can have their timepieces regulated. The "chronometrical chamber" is a vast sweating-room, warmed by steam; each of the hundred marine-watches that the observatory can study at the same time is inclosed in a glass case, in which the air is still heated by a gas-burner, supplied with a regulator, in order to be able to carry the temperature successively from 10° to 18° and to 27° Centigrade. After having tried in this chamber the chronometers that have been intrusted to him by the marine, the observer returns them with the table of their movements.

The Edinburgh Observatory was built in 1818, on Calton Hill, situated northeast of the city, where there has been in existence since the last century an old tower destined for observations of all kinds. The foundation of this establishment was due in the beginning to an astronomical society, organized for this purpose in the ancient capital of Scotland; but, not being able to pay for the instruments ordered, nor to appoint astronomers, it was decided in 1834 to yield the observatory to the Government. The first "astronomer royal for Scotland," charged with the direction of the Edinburgh Observatory, was Henderson, who returned there from the Cape of Good Hope. His successor, Mr. Piazzi Smyth, has established on Calton Hill a time-gun, a cannon of twenty pounds, which, fired by means of an electric current at one o'clock in the afternoon, signals the time to the mariners, and gives them the means of regulating their chronometers. For some

years, the signal was given by a time-ball, as at Greenwich, Glasgow, and elsewhere; this is a great ball suspended from an elevated standard, and made to fall at a precise moment by means of electrical mechanism. Unfortunately, the Edinburgh Observatory is a victim to the centralizing tendencies that rule now in England; its budget is very much reduced, and it is hardly permitted to vegetate. The Royal Observatory of Dublin, founded in 1774, and now under the direction of Mr. Brunnow, Astronomer Royal for Ireland, is not in much better condition. On the contrary, the observatory of the University of Glasgow, and the Ecclesiastical Observatory of Armagh, founded by the Irish primate, are well operated, and render real service.

The celebrated establishment of Kew, which depends at the same time upon the British Association for the Advancement of Science, and upon the Royal Society of London, is the central meteorological observatory of England; new apparatus and new methods are studied there; besides, astronomy, so called, increases its resources by the application of photography to the study of celestial phenomena. Mr. Warren de La Rue has here inaugurated his process of solar observation by the aid of photoheliography, the first decisive step in the eminently fruitful path, the earliest idea of which is due to two French scientists, MM. Fizeau and Léon Foucault.

Mr. Warren de La Rue, who very recently presided over the Astronomical Society of London, is the largest paper-manufacturer in England, and a noteworthy improvement in photographic paper is due to him. He had since 1852 a small observatory at his house in Canonbury, at London, where he undertook his first essays in celestial photography. Five years later, he transported it to the village of Cranford, at the west of London, and since then he has divided his leisure time between this residence, where he studied the moon, and Kew, where solar investigations were carried on under his direction. At the same time, he has given his attention to the improvement of optical instruments. He made himself the mirror of a telescope that he used in most of his observations. But these labors injured his eyesight, and, despairing of being able any longer to make observations himself, he has presented his magnificent collection of instruments to the University of Oxford.

Rich merchants and opulent manufacturers have done themselves honor in founding a series of small observatories, that by their useful labors have assisted the progress of science. That of Mr. Bishop, for instance, erected at first near Regent's Park, then transported to Twickenham, where Messrs. Hind and Pogson discovered so many asteroids; that of Mr. Barclay, the brewer, at Leyton, near London; that of Mr. Lassell, near Liverpool. Like the elder Herschel and Lord Rosse, Mr. Lassell made with his own hands the mirrors of his telescopes, by whose aid he discovered the satellites of Neptune, Saturn,

and Uranus. The last telescope of his construction had four feet of aperture, and was thirty-seven feet long. The impure atmosphere of a manufacturing centre like Liverpool prevented the utilization of the whole power of an instrument of such dimensions. Mr. Lassell resolved to transport it to Malta, where he had already installed, ten years before, a telescope of twenty feet. From 1862 to 1865 the new telescope was constantly turned toward the sky, and employed in scrutinizing its depths. Mr. Lassell discovered more than 600 new nebulæ, whose feeble light, under the humid sky of the North, had escaped the investigations of William Herschel and Lord Rosse. Mr. Lassell is now occupied in the publication of the numerous materials gathered during his two sojourns at Malta.

What an example and what instruction may be found in the long career of William Herschel, who passed half a century in sounding the mysterious depths of the universe! The son of a poor musician—burdened with a numerous family—he embraced the paternal profession, and went, when twenty years old, to try his fortune in England. He barely earned a living by giving music-lessons and directing concerts or oratorios, when he was appointed organist at Halifax, then soon after filled the same office in Bath. He passed his leisure time in studying works on astronomy. As he was not rich enough to purchase a telescope, he went to work, and, after a thousand attempts, succeeded in making, in 1774, a five-foot reflector, with which he observed Saturn's ring. Encouraged by this first success, the organist of Bath entered upon the construction of mirrors of seven feet, then ten, and twenty feet of focus. He made more than 200 before attaining the desired perfection, and the total number of mirrors that he worked upon in succession exceeded 400. In 1781 he had the good fortune to discover the planet Uranus, which extended the boundary of the solar system. He was then forty-three years old. This discovery drew upon him the attention of Europe; George III. granted him a pension and a dwelling at Slough, near Windsor Castle. He then commenced that methodical review of the heavens, by means of which he discovered more than 2,000 nebulæ, and suggested so many new views of the universe. The greatest part of his labor was executed with instruments of moderate dimensions; he rarely used the great telescope of forty feet, the mirror of which was easily tarnished by the action of the moisture of the night; he used it, however, in the discovery of the sixth satellite of Saturn. William Herschel died in 1822; the year before his death, at the age of eighty-three, he communicated his last paper to the Astronomical Society of London, which, since its foundation, had chosen him for president. In all his researches he was assisted by his sister Caroline, who had lived with him ever since she was twenty-two years old, and who aided him in his observations as well as in his calculations. In this way he was able to astonish the scientific world by the rapidity with which his publications succeeded each other. Caroline

Herschel died at Hanover, her native city, in 1849, at the age of ninety-eight. Sir John Herschel, the only son of the great astronomer, worthily continued these illustrious traditions. He resumed and completed the exploration of the heavens commenced by his father, at first at Slough, then at the Cape of Good Hope, where he transported a telescope of twenty feet. He died in 1871, after having contributed, by labors of the highest order, to the progress of science. One of his sons, Alexander Herschel, is equally devoted to astronomical pursuits.

The gigantic telescope of Lord Rosse, which was finished in 1845, the same year when the noble lord was elected representative peer of Ireland, is fifty-five feet in length, and has six feet of aperture. The mirror weighs over four tons, the tube seven tons, and the total weight exceeds eleven tons. The Leviathan, as this giant telescope is called, is suspended between two stone walls at Birr Castle, the hereditary residence of Lord Rosse, in King's County, Ireland. When, in 1826, the young Lord Oxmantown—the title that he then bore—turned his attention toward practical astronomy, there was no constructor capable of furnishing instruments such as he desired. William Herschel had kept the secret of the alloy he used for his mirrors, and the process by which he constructed them. James Short, the greatest constructor of the eighteenth century, so skillful in casting and polishing mirrors, had burned and destroyed before his death his whole stock of tools, in order to remain without a rival. Every thing was then to be discovered anew, and it took Lord Rosse twenty years before he attained the construction of a mirror by means of which he could sound the depths of space and resolve into a mass of stars the most of the nebulæ toward which he directed his gigantic instrument. All the nebulæ, however, are not resolvable; some of them are decidedly agglomerations of cosmical matter not yet condensed. Lord Rosse was the first to demonstrate that the great nebula of Orion, one of the finest in the heavens that belongs to the last category, has within a few years changed its appearance in consequence of the concentration of the matter of which it is formed. This celebrated observer died in 1867; his son worthily continues the labors commenced by the father with such brilliant success.

Lord Rosse preferred mirrors to objectives, on account of the difficulty that attends the manufacture of objectives of large dimensions. But great improvements have since been made; Mr. Clark, an American, constructed in 1862 a powerful instrument, with an object-glass of eighteen and a half inches of aperture. Messrs. Cooke & Son, celebrated constructors of York, finished in 1868 an equatorial of twenty-five inches of aperture, and twenty-nine feet of focal length. The telescope of this gigantic apparatus is mounted on an iron column 350 feet high, and weighs nearly ten tons. This equatorial was constructed for Mr. Newall, proprietor of the submarine cable-works at Gateshead, near Newcastle; it is destined for the island of Madeira, where it will

be installed at the same time with a meridian circle of very large dimensions. Under a sky of exceptional transparency these fine instruments will serve for important researches in the hands of an experienced astronomer, Mr. Marth, the former assistant of Mr. Lassell.

The question of the constitution of nebulæ entered upon a new phase by the appearance of spectrum analysis among the methods applicable to the study of celestial bodies. Since 1869, Messrs. Huggins and Miller have concentrated all their efforts upon this department of research. They have discovered that the unresolvable nebulæ are masses of incandescent gas—they are suns in process of formation; while the resolvable nebulæ are masses of solid matter, hosts of suns already formed. It has also been established by the aid of the spectroscope that comets have a light of their own independent of that which comes from the sun, and is reflected by these wandering stars. These discoveries will give to the little observatory of Upper Tulse Hill an honorable mention in the history of astronomy.

On his side, Mr. Norman Lockyer, at Hampstead, devotes himself to the spectroscopic study of the sun. He sought for a long time to discover a process for observing in a regular manner the rosy protuberances on the solar border, which had thus far been seen only during total eclipses. Hoping that the spectroscope would betray the presence of the red flames on the *contour* of the star at ordinary times, Mr. Lockyer constructed an apparatus of several prisms, and in October, 1868, succeeded in discovering the traces of a protuberance in the spectrum of the solar border. Two months previous, M. Janssen, a French astronomer, who went to India to observe the total eclipse of the 19th of August, was in possession of an analogous method for the study of protuberances, but the announcement of his discovery reached Europe on the very day when Mr. Lockyer announced his own to the scientific world. By enlarging the slit of the spectroscope, the red flames can be seen directly, and the rapid changes followed. Astronomers now draw them at any time. Two years since, Mr. Lockyer succeeded in producing artificial eclipses of the sun by the interposition of a copper disk, which plays the *rôle* of the moon in eclipses, and he thus obtained several drawings of the solar atmosphere with all its minute details.

Mr. Carrington, at Redhill, has chosen another specialty; he has devoted eight years to a long series of observations of solar spots, which have led to remarkable conclusions relative to the constitution of the sun: the unequal velocity of rotation of the different regions of the solar globe would prove the existence of immense currents in the atmosphere of this star. The observatory of Mr. Isaac Fletcher, at Tarn-Bank, Cumberland, was created for the systematic study of double stars, a study which had also for many years occupied the attention of Admiral Smyth, at the observatory of Hartwell, where he was

installed by his friend Dr. Lee. During the last year, one of the rich proprietors of Scotland, Lord Lindsay, founded a splendid observatory at Dun-Echt, for the study of Jupiter's satellites, which Mr. Airy had recommended as the best means for obtaining a knowledge of the mass of that planet. At the same time that he installed his instruments, Lord Lindsay organized at great expense—estimated at $80,000—an expedition to observe at Mauritius the transit of Venus, which took place on the 8th of December, 1874.

This division of labor into numerous specialties is very important for the progress of general science. "Then only," said Bacon, "men will begin to know their strength—when no more all will wish to do the same thing, but the one this, and the other that." The application of photography and spectroscopy to the study of celestial bodies by independent astronomers opens to physical astronomy an entirely new horizon, and promises to this branch a most rapid development. At the same time, it is clear that private establishments cannot be relied upon for the extended researches that demand the continuous labor of many generations of observers. The creation of a public observatory, assured of a permanent existence, and exclusively devoted to researches in physical astronomy, appeared then desirable and expedient. This chasm has just been filled by the foundation of the Oxford Observatory, for the construction of which the senate of that powerful university voted last year considerable funds, and to which Mr. Warren de La Rue presented all his instruments, and especially his famous reflector and his machine for working and polishing mirrors.

The British Association for the Advancement of Science, and the Royal Astronomical Society have exerted a happy influence upon the development of the observatories as well as other English scientific institutions, by creating a tie between learned men led by the same aspirations, in provoking a generous emulation, and in stimulating private enterprise by great examples. By its monthly bulletin, the *Monthly Notices*, the Astronomical Society assures to the useful efforts of amateurs that publicity which is the most powerful incentive to a disinterested devotion.

The numerous and vast colonies that compose the British Empire have not remained, in this respect, behind the mother-country. British India possesses several observatories, of which the first was founded in 1819, at Madras, by the East India Company. In 1841, the King of Oude, still independent at that epoch, erected a rival establishment at Lucknow, and installed there the astronomer Wilcox, with three native assistants. Eight years after, Wilcox having died, the observatory was suppressed, the registers of observation were eaten by the white ants, and the instruments were destroyed during the war that ended by the annexation of Oude. The Rajah of Travancore founded, on the Malabar coast, the observatory of Trevandérem, which has furnished specially good meteorological and magnetic ob-

servations. Finally, there exists at Madras a private observatory, belonging to Mr. Burton Powell.

The Cape of Good Hope was an astronomical station long before a permanent observatory was thought of. From 1751 to 1753 the celebrated Abbé de La Caille prepared his catalogue of the stars of the southern heavens, at the same time that he measured a meridional arc, and that he determined with Lalande, who had been sent to Berlin, the parallax of the moon, by means of a series of simultaneous observations. The immense labors accomplished by La Caille, in his short abode at the Cape, are so much the more worthy of praise as he had to struggle against a climate unfavorable for observation, for in this latitude there are only two months when the days are calm and serene; during the rest of the year the weather is variable, or a violent south wind fills the air with dust, and deprives it of its transparency. In spite of these inconveniences, the Cape is from its geographical situation one of the best stations for the study of the southern heavens, without taking into the account that the necessities of navigation demand the maintenance of an observatory in these regions. But it was not till 1820 that the English Admiralty decided upon the foundation of an observatory at the Cape, which should be constructed upon the model of that of Greenwich. The first director was the Rev. Fearon Fallows, who began regular observations in 1829; but, soon left alone by the departure of his assistant, he was obliged to avail himself of the assistance of his wife, who observed with the mural circle, while he made use of the transit instrument. Fallows died in 1831, and was succeeded by Henderson, to whom Sir Thomas Maclear succeeded in 1834. Better provided with instruments and *personnel* than his predecessor, Mr. Maclear resumed the geodesic operations of La Caille, and measured anew, with the superior means at his command, a meridian arc more extended than the former. Among the other works of the establishment, noteworthy mention must be made of numerous cometic observations. Mr. Maclear resigned his office in 1870, and was replaced by a Greenwich astronomer, Mr. Stone. It should be mentioned here that, outside of the Royal Observatory, Sir John Herschel prepared, from 1833 to 1838, at the Cape of Good Hope, his celebrated catalogue of the nebulæ and double stars of the southern heavens, by the aid of a telescope and an equatorial which he had brought with him.

Since the abode of La Caille at the Cape, no serious attempt had been made to add to our knowledge of the southern half of the heavens, when, in 1821, Sir Thomas Brisbane, then governor of the colony of New South Wales, resolved to supply the want at his own expense. He founded three observatories, one at Makerstown, where Mr. Allen Brown, who has since become the astronomer of the Rajah of Travancore, began a series of meteorological and magnetic observations, the two others at Brisbane and at Paramatta near Sydney. Of the

last two, only that of Paramatta was utilized; the astronomers Rumker and Dunlop prepared there precious catalogues of stars mostly invisible in our hemisphere. Abandoned after the death of Dunlop, this establishment was suppressed in 1855, and replaced by the observatory of Sydney, that the government of New South Wales caused to be constructed at its own expense to satisfy the complaints of the mariners, who found in these regions no means for regulating their chronometers. Already, two years before, the rapid increase of navigation between Europe and Australia in consequence of the discovery of the gold-mines had led the government of the colony of Victoria to found an observatory at Melbourne, which, under the intelligent direction of Mr. Ellery, quickly took rank among the most active establishments. Melbourne has possessed since 1870 a telescope of colossal dimensions. The tube and the mirror, which is four feet in diameter, weigh together nearly nine tons, and the clockwork movement that regulates this immense machine is of such precision that the wire of the micrometer follows a fixed star for more than an hour. As a precautionary measure, two four-feet mirrors were sent from London instead of one; unfortunately, they were both injured in the passage, it was necessary to repolish them, and, in spite of the impatience and bad humor of the inhabitants of Melbourne, all the results promised from this great telescope have not yet been attained. Instruments of this kind are so much the more delicate as their dimensions are increased, and they demand long practice before being used with success. At present the greater part of the work of the Melbourne establishment is carried on with the ordinary implements of observatories. Mr. Ellery arranged with the astronomers at Sydney and at the Cape for undertaking a grand review of the southern heavens, which were divided into zones, and the three stations shared the systematic exploration. A large portion of these observations has been already published.

The rapid picture we have sketched will give an idea of the extraordinary flight practical astronomy has taken not only on the soil of the British Isles, but upon every point of the globe where the Anglo-Saxon race has planted its colonies. The necessities of navigation have been the prominent motive for the creation of some of the most important English observatories; but the volunteers in science have also done no inconsiderable portion of the common work. The landed aristocracy, the higher branches of trade, the arts and manufactures, hold the honor of being united with the professional men of science, or at least of coöperating in their labors, by an enlightened munificence. Can a better use be made of fortune or leisure? It has been said concerning the organization of the Greenwich Observatory that the essentially practical and utilitarian spirit of the English is manifested also in science, since all the labor in Greenwich is directed toward a special purpose, the incessant improvement of that portion of astronomy that renders so great service to navigation. However,

in seeing that varied activity displayed in the numerous observatories of Great Britain, and including in its sphere every branch of celestial science, must it not be granted that something else is developed besides a tendency to the positive or the research of applications immediately useful?

It is worthy of note that the efforts of amateurs are particularly directed toward the realization of instruments of unusual dimensions, destined to sound the depths of the firmament. But the construction of mirrors or object-glasses of very great diameter is of fundamental interest for the progress of physical astronomy. Not only is the brightness of images proportioned to the aperture, that is, to the diameter of the instrument, but the optical power, or the faculty of separating two luminous points closely united, increases also in a direct ratio with the aperture. According to Léon Foucault, an aperture of at least thirty-nine inches is required to distinguish two points from each other whose apparent distance is equal to the tenth of a second of an arc. The two Herschels, Lord Rosse, Mr. Lassell, finally the commission that had charge of the construction of the Melbourne telescope, gave the preference to telescopes with a metallic mirror; is this preference justifiable? The question admits of doubt. The mirrors of silvered glass in which Léon Foucault attained so great perfection reflect a larger portion of light than metal mirrors; according to the experience of Mr. Wolf, a telescope with a silvered mirror reflects 80 per cent. of the incident light, while with metallic mirrors only 40 per cent. can be utilized. Besides, glass mirrors are lighter, and it is easy to silver them anew when the surface is tarnished. Metal mirrors need to be frequently repolished, which is no inconsiderable work; the experience at Melbourne affords an illustration of this fact. It is then with good reason that telescopes of the Foucault system are preferred in France. Finally, to sum up every thing, the future is perhaps not for great mirrors, but for great object-glasses. Indeed, with an equal aperture, a refracting telescope furnished with a good object-glass far surpasses a reflecting telescope; the great refractors of Dorpat and Pultowa rival reflectors of a double or triple diameter. We have already seen that a refractor of twenty-five inches aperture has been completed by Messrs. Cooke. The Observatory of Paris has possessed since 1855 a disk of flint-glass and one of crown-glass whose dimensions are sufficient to make an object-glass of nearly thirty inches in diameter, and in 1868 the Government voted $80,000 for the construction of a refractor which should be furnished with this object-glass and for that of a reflector with nearly four feet aperture. The mirror of the reflector, the work of which was intrusted to Mr. Martin, is almost finished; the cutting of the object-glass will be immediately commenced. This will be the most powerful glass that has yet been undertaken, and this time it is France that will take the precedence of other nations. It is hoped that this will

not be the only effort attempted for the purpose of making practical astronomy flourish among us with a splendor worthy of a glorious past.

THE ATMOSPHERE IN RELATION TO FOG-SIGNALING.

By JOHN TYNDALL, LL. D., F. R. S.

INTRODUCTION.

THE cloud produced by the puff of a locomotive can quench the rays of the noonday sun; it is not therefore surprising that in dense fogs our most powerful coast-lights, including even the electric light, should become useless to the mariner.

Disastrous shipwrecks are the consequence. During the last ten years no less than 273 vessels have been reported as totally lost on our own coasts in fog or thick weather. The loss, I believe, has been far greater on the American seaboard, where trade is more eager and fogs more frequent than they are here. No wonder, then, that earnest efforts should be made to find a substitute for light in sound-signals, powerful enough to give warning and guidance to mariners while still at a safe distance from the shore.

Such signals have been established to some extent upon our own coasts, and to a still greater extent along the coasts of Canada and the United States. But the evidence as to their value and performance is of the most conflicting character, and no investigation sufficiently thorough to clear up the uncertainty has hitherto been made. In fact, while the *velocity* of sound has formed the subject of refined and repeated experiment by the ablest philosophers, the publication of Dr. Derham's celebrated paper in the "Philosophical Transactions" for 1708 marks the latest systematic inquiry into the causes which affect the *intensity* of sound in the atmosphere.

Jointly with the Elder Brethren of the Trinity House, and as their scientific adviser, I have recently had the honor of conducting an inquiry designed to fill the blank here indicated.

One or two brief references will suffice to show the state of the question when this investigation began. "Derham," says Sir John Herschel, "found that fogs and falling rain, but more especially snow, tend powerfully to obstruct the propagation of sound, and that the same effect was produced by a coating of fresh-fallen snow on the ground, though when glazed and hardened at the surface by freezing it had no such influence."[1]

In a very clear and able letter addressed to the President of the Board of Trade in 1863,[2] Dr. Robinson, of Armagh, thus summarizes our knowledge of fog-signals:

[1] "Essay on Sound," par. 21. [2] "Report of the British Association" for 1863, p. 105.

"Nearly all that is known about fog-signals is to be found in the 'Report on Lights and Beacons;' and of it much is little better than conjecture. Its substance is as follows:

"'Light is scarcely available for this purpose. Blue lights are used in the Hoogly; but it is not stated at what distance they are visible in fog; their glare may be seen farther than their flame.[1] It might, however, be desirable to ascertain how far the electric light or its flash can be traced.[2]

"'Sound is the only known means really effective; but about it testimonies are conflicting, and there is scarcely one fact relating to its use as a signal which can be considered as established. Even the most important of all, the distance at which it ceases to be heard, is undecided.

"'Up to the present time all signal-sounds have been made in air, though this medium has grave disadvantages: its own currents interfere with the sound-waves, so that a gun or bell which is heard several miles *down* the wind is inaudible more than a few furlongs *up* it. A still greater evil is that it is least effective when most needed; for fog is a powerful damper of sound.'"

Dr. Robinson here expresses the universally prevalent opinion, and he then assigns the theoretic cause. Fog, he says, "is a mixture of air and globules of water, and, at each of the innumerable surfaces where these two touch, a portion of the vibration is reflected and lost.[3] . . . Snow produces a similar effect, and one still more injurious."

Reflection being thus considered to take place at the surfaces of the suspended particles, it followed that the greater the number of particles, or, in other words, the denser the fog, the more injurious would be its action upon sound. Hence optic transparency came to be considered a measure of acoustic transparency. On this point Dr. Robinson, in the letter referred to, expresses himself thus: "At the outset, it is obvious that, to make experiments *comparable*, we must have some measure of the fog's power of stopping sound, without attending to which the most anomalous results may be expected. It seems probable that this will bear some simple relation to its opacity to light, and that the distance at which a given object, as a flag or pole, disappears, may be taken as the measure. . . . Still, clear air" was regarded in this letter as the best vehicle of sound, the alleged action of fogs, rain, and snow, being ascribed to their rendering the atmosphere "a discontinuous medium."

Prior to this investigation the views here enunciated were those universally entertained. That sound is unable to penetrate fogs was taken to be "a matter of common observation." The bells and horns of ships were affirmed "not to be heard so far in fogs as in clear weather." In the fogs of London, the noise of the carriage-wheels was reported to be so much diminished that "they seem to be at a distance when really close by." My knowledge does not inform me of the existence of any other source for these opinions regarding the

[1] A very sagacious remark, as observation proves.

[2] Powerful electric lights have been since established, and found ineffectual.

[3] This is also Sir John Herschel's way of regarding the subject. "Essay on Sound," par. 38.

deadening power of fog than the paper of Derham, published one hundred and sixty-seven years ago. In consequence of their *a priori* probability, his conclusions seem to have been transmitted unquestioned from generation to generation of scientific men.

INSTRUMENTS AND OBSERVATIONS.—On the 19th of May, 1873, this inquiry began. The South Foreland, near Dover, was chosen as the signal-station, steam-power having been already established there to work two powerful magneto-electric lights. The observations were mostly made afloat, one of the yachts of the Trinity Corporation being usually employed for this purpose. Two stations had been established, one at the top, the other at the bottom, of the South-Foreland Cliff; and, at each, trumpets, air-whistles, and steam whistles of great size, were mounted. The whistles first employed were of English manufacture. To these were afterward added a large United States whistle, also a Canadian whistle, of great reputed power.

On the 8th of October another instrument, which has played a specially important part in these observations, was introduced. This was a steam-siren, constructed and patented by Mr. Brown, of New York, and introduced by Prof. Henry into the light-house system of the United States. As an example of international courtesy worthy of imitation, I refer with pleasure to the fact that, when informed by Major Elliott, of the United States Army, that our experiments had begun, the Light-house Board at Washington, of their own spontaneous kindness, forwarded to us for trial a very noble instrument of this description, which was immediately mounted at the South Foreland.

The principle of the siren is easily understood. A musical sound is produced when the tympanic membrane is struck periodically with sufficient rapidity. The production of these tympanic shocks by puffs of air was first realized by Dr. Robinson, and his device was the first and simplest form of the siren. A stopcock was so constructed that it opened and shut the passage of a pipe 720 times in a second. Air from the wind-chest of an organ being allowed to pass along the pipe during the rotation of the cock, a musical sound was most smoothly uttered. A great step was made in the construction of the instrument by Cagniard de la Tour, who gave it its present name. He employed a box with a perforated lid, and above the lid a similarly perforated disk capable of rotation. The perforations were oblique, so that when wind was driven through the lid, it so impinged upon the apertures of the disk as to set it in motion. No separate mechanism was therefore required to turn the disk. When the perforations of lid and disk coincided, a puff escaped; when they did not coincide, the current of air was cut off. In this way impulses were imparted to the air, and sound-waves generated. The siren has been greatly improved by Dove, and specially so by Helmholtz. Even in its small form, it can produce sounds of great intensity.

In the steam-siren, as in the ordinary one, a fixed disk and a rotating disk are employed, but radial slits are used instead of circular apertures. One disk is fixed vertically across the throat of a conical trumpet 16½ feet long, 5 inches in diameter where the disk crosses it, and gradually opening out till at the other extremity it reaches a diameter of two feet three inches. Behind the fixed disk is the rotating one, which is driven by separate mechanism. The trumpet is mounted on a boiler. In our experiments, steam of 70 lbs. pressure was for the most part employed. Just as in the ordinary siren, when the radial slits of the two disks coincide, and then only, a strong puff of steam escapes. Sound-waves of great intensity are thus sent through the air, the pitch of the note depending on the velocity of rotation.

To the siren, trumpets, and whistles, were added three guns—an 18-pounder, a 5½-inch howitzer, and a 13-inch mortar. In our summer experiments all three were fired; but the howitzer having shown itself superior to the other guns, it was chosen in our autumn experiments, as not only a fair but a favorable representative of this form of signal. The charges fired were for the most part those now employed at Holyhead, Lundy Island, and the Kish light-vessel—namely, 3 lbs. of powder. Gongs and bells were not included in this inquiry, because previous observations had clearly proved their inferiority to the trumpets and whistles.

On the 19th of May the instruments tested were:

On the top of the cliff:

1. Two brass trumpets or horns, 11 feet 2 inches long, 2 inches in diameter at the mouthpiece, and opening out at the other end to a diameter of 22½ inches. They were provided with vibrating steel reeds 9 inches long, 2 inches wide, and ¼ inch thick, and were sounded by air of 18 lbs. pressure.

2. A whistle shaped like that of a locomotive, 6 inches in diameter, also sounded by air of 18 lbs. pressure.

3. A steam-whistle, 12 inches in diameter, attached to a boiler, and sounded by steam of 64 lbs. pressure.

At the bottom of the cliff:

4. Two trumpets or horns, of the same size and arrangement as those above, and sounded by air of the same pressure. They were mounted vertically on the reservoir of compressed air; but within about two feet of their extremities they were bent at a right angle, so as to present their mouths to the sea.

5. A 6-inch air-whistle, similar to the one above, and sounded by the same means.

The upper instruments were 235 feet above high-water mark, the lower ones 40 feet. A vertical distance of 195 feet, therefore, separated the instruments. A shaft, provided with a series of twelve ladders, led from the one to the other.

Comparative experiments made at the outset gave a slight advantage to the upper instruments. They, therefore, were for the most part employed throughout the subsequent inquiry.

Our first experiments were a preliminary discipline rather than an organized effort at discovery. On May 19th the maximum distance reached by the sound was about 3½ miles.[1] The wind, however, was high and the sea rough, so that local noises interfered to some extent with our appreciation of the sound.

Mariners express the strength of the wind by a series of numbers extending from 0 = calm to 12 = a hurricane, a little practice in common producing a remarkable unanimity between different observers as regards the force of the wind. Its force on May 19th was 6, and it blew at right angles to the direction of the sound.

The same instruments on May 20th covered a greater range of sound; but not much greater, though the disturbance due to local noises was absent. At four miles' distance in the axes of the horns they were barely heard, the air at the time being calm, the sea smooth, and all other circumstances exactly those which have been hitherto regarded as most favorable to the transmission of sound. We crept a little farther away, and by stretched attention managed to hear at intervals, at a distance of six miles, the faintest hum of the horns. A little farther on we again halted; but though local noises were absent, and though we listened intently, we heard nothing.

This position, clearly beyond the range of whistles and trumpets, was expressly chosen with the view of making what might be considered a decisive comparative experiment between horns and guns as instruments for fog-signaling. The distinct report of the twelve o'clock gun fired at Dover on the 19th suggested this comparison, and through the prompt courtesy of General Sir A. Horsford we were enabled to carry it out. At half-past twelve precisely the puff of an 18-pounder, with a three-lb. charge, was seen at Dover Castle, which was about a mile farther off than the South Foreland. Thirty-six seconds afterward the loud report of the gun was heard, its complete superiority over the trumpets being thus, to all appearance, demonstrated.

We clinched this observation by steaming out to a distance of 8½ miles, where the report of a second gun was well heard by all of us. At a distance of 10 miles the report of a third gun was heard by some, and at 9.7 miles the report of a fourth gun was heard by all.

The result seemed perfectly decisive. Applying the law of inverse squares, the sound of the gun at a distance of 6 miles from the Foreland must have had more than two and a half times the intensity of the sound of the trumpets. It would hardly have been rash under the circumstances to have reported without qualification the superiority of the gun as a fog-signal. No single experiment is, to my

[1] In all cases nautical miles are meant.

knowledge, on record to prove that a sound once predominant would not be always predominant, or that the atmosphere on different days would show preferences to different sounds. On many subsequent occasions, however, the sound of the horns proved distinctly superior to that of the gun. This *selective* power of the atmosphere revealed itself more strikingly in our autumn experiments than in our summer ones; and it was sometimes illustrated within a few hours of the same day; of two sounds, for example, one might have the greatest range at 10 A. M., and the other the greatest range at 2 P. M.

In the experiments on May 19th and 20th the superiority of the trumpets over the whistles was decided; and, indeed, with few exceptions, this superiority was maintained throughout the inquiry. But there were exceptions. On June 2d, for example, the whistles rose in several instances to full equality with, and on rare occasions subsequently even surpassed, the horns. The sounds were varied from day to day, and various shiftings of the horns and reeds were resorted to, with a view of bringing out their maximum power. On the date last mentioned a single horn was sounded, two were sounded, and three were sounded, together; but the utmost range of the loudest sound, even with the paddles stopped, did not exceed 6 miles. With the view of concentrating their power, the axes of the horns had been pointed in the same direction, and, unless stated to the contrary, this in all subsequent experiments was the case.

On June 3d the three guns already referred to were permanently mounted at the South Foreland. They were ably served by gunners from Dover Castle.

On the same day dense clouds quite covered the firmament, some of them particularly black and threatening, but a marked advance was observed in the transmissive power of the air. At a distance of 6 miles the horn-sounds were not quite quenched by the paddle-noises; at 8 miles the whistles were heard, and the horns better heard; while at 9 miles, with the paddles stopped, the horn-sounds alone were fairly audible. During the day's observations a remarkable and instructive phenomenon was observed. Over us rapidly passed a torrential shower of rain, which, according to Derham, is a potent damper of sound. We could, however, notice no subsidence of intensity as the shower passed. It is even probable that, had our minds been free from bias, we should have noticed an augmentation of the sound, such as occurred with the greatest distinctness on various subsequent occasions during violent rain.

The influence of "beats" was tried on June 3d, by throwing the horns slightly out of unison; but, though the beats rendered the sound characteristic, they did not seem to augment the range. At a distance from the station curious fluctuations of intensity were noticed. Not only did the different blasts vary in strength, but sudden swellings and fallings off, even of the same blast, were observed. This was not

due to any variation on the part of the instruments, but purely to the changes of the medium traversed by the sound. What these changes were shall be indicated subsequently.

The range of our best horns on June 10th was 8¾ miles. The guns at this distance were very feeble. That the loudness of the sound depends on the shape of the gun was proved by the fact that thus far the howitzer, with a three-lb. charge, proved more effective than the other guns.

On June 25th a gradual improvement in the transmissive power of the air was observed from morning to evening; but at the last the maximum range was only moderate. The fluctuations in the strength of the sound were remarkable, sometimes sinking to inaudibility and then rising to loudness. A similar effect, due to a similar cause, is often noticed with church-bells. The acoustic transparency of the air was still further augmented on the 26th: at a distance of 9¼ miles from the station the whistles and horns were plainly heard against a wind with a force of four; white on the 25th, with a favoring wind, the maximum range was only 6½ miles. Plainly, therefore, something else than the wind must be influential in determining the range of the sound.

On Tuesday, July 1st, observations were made on the decay of the sound at various angular distances from the axis of the horn. As might be expected, the sound in the axis was loudest, the decay being gradual on both sides. In the case of the gun, however, the direction of pointing has very little influence.

The day was acoustically clear; at a distance of 10 miles the horn yielded a plain sound, while the American whistle seemed to surpass the horn. Dense haze at this time quite hid the Foreland. At 10½ miles occasional blasts of the horn came to us, but, after a time, all sound ceased to be audible; it seemed as if the air, after having been exceedingly transparent, had become gradually more opaque to the sound.

At 4.45 P. M. we took the master of the Varne light-ship on board the Irene. He and his company had heard the sound at intervals during the day, although he was dead to windward and distant 12¾ miles from the source of sound.

Here a word of reflection on our observations may be fitly introduced. It is, as already shown, an opinion entertained in high quarters that the waves of sound are reflected at the limiting surfaces of the minute particles which constitute haze and fog, the alleged waste of sound in fog being thus explained. If, however, this be an efficient practical cause of the stoppage of sound, and if clear, calm air be, as alleged, the best vehicle, it would be impossible to understand how to-day, in a thick haze, the sound reached a distance of 12¾ miles, while on May 20th, in a calm and hazeless atmosphere, the maximum range was only from 5 to 6 miles. Such facts foreshadow a revolution in our notions regarding the action of haze and fogs upon sound.

An interval of 12 hours sufficed to change in a surprising degree the acoustic transparency of the air. On the 1st of July the sound had a range of nearly 13 miles; on the 2d the range did not exceed 4 miles.

CONTRADICTORY RESULTS.—Thus far the investigation proceeded with hardly a gleam of a principle to connect the inconstant results. The distance reached by the sound on the 19th of May was 3½ miles; on the 20th it was 5½ miles; on the 2d of June, 6 miles; on the 3d, more than 9 miles; on the 10th it was also 9 miles; on the 25th it fell to 6½ miles; on the 26th it rose again to more than 9¼ miles; on the 1st of July, as we have just seen, it reached 12¾, whereas on the 2d the range shrunk to 4 miles. None of the meteorological agents observed could be singled out as the cause of these fluctuations. The wind exerts an acknowledged power over sound, but it could not account for these phenomena. On the 25th of June, for example, when the range was only 6½ miles, the wind was favorable; on the 26th, when the range exceeded 9¼ miles, it was opposed to the sound. Nor could the varying optical clearness of the atmosphere be invoked as an explanation; for, on July 1st, when the range was 12¾ miles, a thick haze hid the white cliffs of the Foreland, while on many other days, when the acoustic range was not half so great, the atmosphere was optically clear. Up to July 3d all remained enigmatical; but on this date observations were made which seemed to me to displace surmise and perplexity by the clearer light of physical demonstration.

SOLUTION OF CONTRADICTIONS.—On July 3d we first steamed to a point 2.9 miles southwest-by-west of the signal station. No sounds, not even the guns, were heard at this distance. At two miles they were equally inaudible. But this being a position at which the sounds, though strong in the axis of the horn, invariably subsided, we steamed to the exact bearing from which our observations had been made on July 1st. At 2.15 P. M., and at a distance of 3¾ miles from the station, with calm, clear air and a smooth sea, the horns and whistle (American) were sounded, but they were inaudible. Surprised at this result, I signaled for the guns. They were all fired, but, though the smoke seemed at hand, no sound whatever reached us. On July 1st, in this bearing, the observed range of both horns and guns was 10½ miles, while, on the bearing of the Varne light-vessel, it was nearly 13 miles. We steamed in to 3 miles, paused, and listened with all attention; but neither horn nor whistle was heard. The guns were again signaled for; five of them were fired in succession, but not one of them was heard. We steamed on in the same bearing to 2 miles, and had the guns fired point-blank at us. The howitzer and the mortar, with 3-lb. charges, yielded a feeble thud, while the 18-pounder was wholly unheard. Applying the law of inverse squares, it follows that, with the air and sea, according to accepted notions, in a far worse condi-

tion, the sound at two miles' distance on July 1st must have had more than forty times the intensity which it possessed at the same distance at 3 P. M. on the 3d.

"On smooth water," says Sir John Herschel, "sound is propagated with remarkable clearness and strength." Here was the condition; still, with the Foreland so close to us, the sea so smooth, and the air so transparent, it was difficult to realize that the guns had been fired, or the trumpets blown at all. What could be the reason? Had the sound been converted by internal friction into heat, or had it been wasted in partial reflections at the limiting surfaces of non-homogeneous masses of air? I ventured, two or three years ago, to say something regarding the function of the imagination in science, and, notwithstanding the care then taken, to define and illustrate its real province, some persons, among whom were one or two able men, deemed me loose and illogical. They misunderstood me. The faculty to which I referred was that power of visualizing processes in space, and the relations of space itself, which must be possessed by all great physicists and geometers. Looking, for example, at two pieces of polished steel, we have not a sense, or the rudiment of a sense, to distinguish the inner condition of the one from that of the other. And yet they may differ materially, for one may be a magnet, the other not. What enabled Ampère to surround the atoms of such a magnet with channels in which electric currents ceaselessly run, and to deduce from these pictured currents all the phenomena of ordinary magnetism? What enabled Faraday to visualize his lines of force, and make his mental picture a guide to discoveries which have rendered his name immortal? Assuredly it was the disciplined imagination. Figure the observers on the deck of the Irene, with the invisible air stretching between them and the South Foreland, knowing that it contained something which stifled the sound, but not knowing what that something is. Their senses are not of the least use to them; nor could all the philosophical instruments in the world render them any assistance. They could not, in fact, take a single step toward the solution without the formation of a mental image; in other words, without the exercise of the imagination.

Sulphur in homogeneous crystals is exceedingly transparent to radiant heat, whereas the ordinary brimstone of commerce is highly impervious to it—the reason being that the brimstone does not possess the molecular continuity of the crystal, but is a mere aggregate of minute grains not in perfect optical contact with each other. Where this is the case, a portion of the heat is always reflected on entering and on quitting a grain; hence, when the grains are minute and numerous, this reflection is so often repeated that the heat is entirely wasted before it can plunge to any depth into the substance. The same remark applies to snow, foam, clouds, and common salt, indeed to all transparent substances in powder; they are all impervious to

light, not through the immediate absorption or extinction of the light, but through repeated internal reflection.

Humboldt, in his observations at the Falls of the Orinoco, is known to have applied these principles to sound. He found the noise of the falls far louder by night than by day, though in that region the night is far noisier than the day. The plain between him and the falls consisted of spaces of grass and rock intermingled. In the heat of the day he found the temperature of the rock to be considerably higher than that of the grass. Over every heated rock, he concluded, rose a column of air rarefied by the heat; its place being supplied by the descent of heavier air. He ascribed the deadening of the sound to the reflections which it endured at the limiting surfaces of the rarer and denser air. This philosophical explanation made it generally known that a non-homogeneous atmosphere is unfavorable to the transmission of sound.

But what, on July 3d, not with the variously-heated plain of Antures, but with a calm sea as a basis for the atmosphere, could so destroy its homogeneity as to enable it to quench in so short a distance so vast a body of sound? My course of thought at the time was thus determined. As I stood upon the deck of the Irene, pondering the question, I became conscious of the exceeding power of the sun beating against my back and heating the objects near me. Beams of equal power were falling on the sea, and must have produced copious evaporation. That the vapor generated should so rise and mingle with the air as to form an absolutely homogeneous medium was in the highest degree improbable. It would be sure, I thought, to rise in invisible streams, breaking through the superincumbent air, now at one point, now at another, thus rendering the air *flocculent* with wreaths and striæ, charged in different degrees with the buoyant vapor. At the limiting surfaces of these spaces, though invisible, we should have the conditions necessary to the production of partial echoes and the consequent waste of sound. Ascending and descending air-currents, of different temperatures, as far as they existed, would also contribute to the effect.

Curiously enough, the conditions necessary for the testing of this explanation immediately set in. At 3.15 P. M., a solitary cloud threw itself athwart the sun, and shaded the entire space between us and the South Foreland. The heating of the water, and the production of vapor, were suddenly checked by the interposition of this screen; hence the probability of suddenly-improved transmission. To test this inference, the steamer was immediately turned and urged back to our last position of inaudibility. The sounds, as I expected, were distinctly though faintly heard. This was at 3 miles' distance. At 3¾ miles the guns were fired, both point-blank and elevated. The faintest pop was all that we heard; but we did hear a pop, whereas we had previously heard nothing, either here or three-quarters of a

mile nearer. We steamed out to 4¼ miles, where the sounds were for a moment faintly heard; but they fell away as we waited, and though the greatest quietness reigned on board, and though the sea was without a ripple, we could hear nothing. We could plainly see the steam-puffs which announced the beginning and the end of a series of trumpet-blasts, but the blasts themselves were quite inaudible.

It was now 4 P. M., and my intention at first was to halt at this distance, which was beyond the sound-range, but not far beyond it, and see whether the lowering of the sun would not restore the power of the atmosphere to transmit the sound. But, after waiting a little, the anchoring of a boat was suggested, so as to liberate the steamer for other work; and, though loath to lose the anticipated revival of the sounds myself, I agreed to this arrangement. Two men were placed in the boat and requested to give all attention, so as to hear the sound if possible. With perfect stillness around them, they heard nothing. They were then instructed to hoist a signal if they should hear the sounds, and to keep it hoisted as long as the sounds continued.

At 4.45 we quitted them and steamed toward the South Sand Head light-ship. Precisely fifteen minutes after we had separated from them the flag was hoisted: the sound had at length succeeded in piercing the body of air between the boat and the shore.

We continued our journey to the light-ship, went on board, heard the report of the lightsmen, and returned to our anchored boat. We then learned that when the flag was hoisted the horn-sounds were heard, that they were succeeded after a little time by the whistle-sounds, and that both increased in intensity as the evening advanced. On our arrival, of course we heard the sounds ourselves.

We pushed the test further by steaming farther out. At 5¾ miles, we halted and heard the sounds; at 6 miles we heard them distinctly, but so feebly that we thought we had reached the limit of the sound-range; but while we waited the sounds rose in power. We steamed to the Varne buoy, which is 7¾ miles from the signal-station, and heard the sounds there better than at 6 miles' distance. We continued our course outward to 10 miles, halted there for a brief interval, but heard nothing.

Steaming, however, on to the Varne light-ship, which is situated at the other end of the Varne shoal, we hailed the master, and were informed by him that up to 5 P. M. nothing had been heard, but that at that hour the sounds began to be audible. He described one of them as "very gross, resembling the bellowing of a bull," which very accurately characterizes the sound of the large American steam-whistle. At the Varne light-ship, therefore, the sounds had been heard toward the close of the day, though it is 12¾ miles from the signal-station. I think it probable that, at a point 2 miles from the Foreland, the sound at 5 P. M. possessed fifty times the intensity which it possessed at 2 P. M. To such undreamt-of fluctuations is the atmosphere liable. On

our return to Dover Bay, at 10 P. M., we heard the sounds, not only distinct but loud, where nothing could be heard in the morning.

REMARKABLE INSTANCES OF ACOUSTIC OPACITY.—In his excellent lecture entitled "Wirkungen aus der Ferne," Dove has collected some striking cases of the interception of sound. The Duke of Argyll has also favored me with some highly-interesting illustrations. But nothing of this description that I have read equals in point of interest the following account of the battle of Gain's Farm, for which I am indebted to the Rector of the University of Virginia:

"LYNCHBURG, VA., *March* 19, 1874.

"SIR: I have just read with great interest your lecture of January 16th, on the acoustic transparency and opacity of the atmosphere. The remarkable observations you mention induce me to state to you a fact which I have occasionally mentioned, but always, where I am not well known, with the apprehension that my veracity would be questioned. It made a strong impression on me at the time, but was an insoluble mystery until your discourse gave me a possible solution.

"On the afternoon of June 28, 1862, I rode, in company with General G. W. Randolph, then Secretary of War of the Confederate States, to Price's house, about nine miles from Richmond; the evening before General Lee had begun his attack on McClellan's army, by crossing the Chickahominy about four miles above Price's, and driving in McClellan's right wing. The battle of Gain's Farm was fought the afternoon to which I refer. The valley of the Chickahominy is about one and a half mile wide from hill-top to hill-top. Price's is on one hill-top, that nearest to Richmond; Gain's Farm, just opposite, is on the other, reaching back in a plateau to Cold Harbor.

"Looking across the valley I saw a good deal of the battle, Lee's right resting in the valley, the Federal left wing the same. My line of vision was nearly in the line of the lines of battte. I saw the advance of the Confederates, their repulse two or three times, and in the gray of the evening the final retreat of the Federal forces.

"I distinctly saw the musket-fire of both lines, the smoke, the individual discharges, the flash of the guns. I saw batteries of artillery on both sides come into action and fire rapidly. Several field-batteries on each side were plainly in sight. Many more were hid by the timber which bounded the range of vision.

"Yet, looking for nearly two hours, from about 5 to 7 P. M. on a midsummer afternoon, at a battle in which at least 50,000 men were actually engaged, and doubtless at least 100 pieces of field-artillery, through an atmosphere optically as limpid as possible, *not a single sound of the battle* was audible to General Randolph and myself. I remarked it to him at the time as astonishing.

"Between me and the battle was the deep, broad valley of the Chickahominy, partly a swamp, shaded by the declining sun, by the hills and forest in the west (my side). Part of the valley on each side of the swamp was cleared; some in cultivation, some not. Here were conditions capable of providing several belts of air, varying in the amount of watery vapor (and probably in temperature), arranged like laminæ at right angles to the acoustic waves as they came from the battle-field to me.

"Respectfully, your obedient servant, R. G. H. KEAN.

"Prof. JOHN TYNDALL."

I learn from a subsequent letter that during the battle the air was still.—J. T.

ECHOES FROM INVISIBLE ACOUSTIC CLOUDS.—But both the argument and the phenomena have a complementary side, which we have now to consider. A stratum of air less than three miles thick on a calm day has been proved competent to stifle both the cannonade and the horn-sounds employed at the South Foreland; while, according to the foregoing explanation, this result was due to the reflection of the sound from invisible *acoustic clouds* which filled the atmosphere on a day of perfect *optical* transparency. But, granting this, it is incredible that so great a body of sound could utterly disappear in so short a distance without rendering some account of itself. Supposing, then, instead of placing ourselves behind the acoustic cloud, we were to place ourselves in front of it, might we not, in accordance with the law of conservation, expect to receive by reflection the sound which had failed to reach us by transmission? The case would then be strictly analogous to the reflection of light from an ordinary cloud to an observer between it and the sun.

My first care in the early part of the day in question was to assure myself that our inability to hear the sound did not arise from any derangement of the instruments on shore. Accompanied by the private secretary of the Deputy Master of the Trinity House, at 1 P. M. I was rowed to the shore, and landed at the base of the South Foreland Cliff. The body of air which had already shown such extraordinary power to intercept the sound, and which manifested this power still more impressively later in the day, was now in front of us. On it the sonorous waves impinged, and from it they were sent back with astonishing intensity. The instruments, hidden from view, were on the summit of a cliff 235 feet above us, the sea was smooth and clear of ships, the atmosphere was without a cloud, and there was no object in sight which could possibly produce the observed effect. From the perfectly transparent air the echoes came, at first with a strength apparently little less than that of the direct sound, and then dying gradually and continuously away. A remark made by my talented companion in his note-book at the time shows how the phenomenon affected him: "Beyond saying that the echoes seemed to come from the expanse of ocean, it did not appear possible to indicate any more definite point of reflection." Indeed, no such point was to be seen; the echoes reached us, as if by magic, from the invisible acoustic clouds with which the optically transparent atmosphere was filled. The existence of such clouds in all weathers, whether optically cloudy or serene, is one of the most important points established by this inquiry.

Here, in my opinion, we have the key to many of the mysteries and discrepancies of evidence which beset this question. The foregoing observations show that there is no need to doubt either the veracity

or the capability of the conflicting witnesses, for the variations of the atmosphere are more than sufficient to account for theirs. The mistake, indeed, hitherto has been, not in reporting incorrectly, but in neglecting the monotonous operation of repeating the observations during a sufficient time. I shall have occasion to remark subsequently on the mischief likely to arise from giving instruction to mariners founded on observations of this incomplete character.

It required, however, long pondering and repeated observation before this conclusion took firm root in my mind; for it was opposed to the results of great observers, and to the statements of celebrated writers. In science, as elsewhere, a mind of any depth, which accepts a doctrine undoubtingly, discards it unwillingly. The question of aërial echoes has an historic interest. While cloud-echoes have been accepted as demonstrated by observation, it has been hitherto held as established that audible echoes never occur in optically clear air. We owe this opinion to the admirable report of Arago on the experiments made to determine the velocity of sound at Montlhéry and Villejuif in 1822.[1] Arago's account of the phenomenon observed by him and and his colleagues is as follows: "Before ending this note we will only add that the shots fired at Montlhéry were accompanied by a rumbling like that of thunder, which lasted from 20 to 25 seconds. Nothing of this kind occurred at Villejuif. Once we heard two distinct reports, a second apart, of the Montlhéry cannon. In two other cases the report of the same gun was followed by a prolonged rumbling. These phenomena never occurred without clouds. Under a clear sky the sounds were single and instantaneous. May we not, therefore, conclude that the multiple reports of the Montlhéry gun heard at Villejuif were echoes from the clouds, and may we not accept this fact as favorable to the explanation given by certain physicists of the rolling of thunder?"

I think both the fact and the inference need reconsideration. For our observations prove to demonstration that air of perfect visual transparency is competent to produce echoes of great intensity and long duration. The subject is worthy of additional illustration. On the

[1] Sir John Herschel gives the following account of Arago's observation: "The rolling of thunder has been attributed to echoes among the clouds; and, if it is considered that a cloud is a collection of particles of water, however minute, in a liquid state, and therefore each individually capable of reflecting sound, there is no reason why very loud sounds should not be reverberated confusedly (like bright lights) from a cloud. And that such is the case has been ascertained by direct observation on the sound of cannon. Messrs. Arago, Matthieu, and Prony, in their experiments on the velocity of sound, observed that under a perfectly clear sky the explosions of their guns were always single and sharp; whereas, when the sky was overcast, and even when a cloud came in sight over any considerable part of the horizon, they were frequently accompanied by a long-continued roll like thunder."—("Essay on Sound," par. 38.) The distant clouds would imply a long interval between sound and echo, but nothing of the kind is reported.

8th of October, as already stated, the siren was established at the South Foreland. I visited the station on that day, and listened to its echoes. They were far more powerful than those of the horn. Like the others, they were perfectly continuous, and faded, as if into distance, gradually away. The direct sound seemed rendered complex and multitudinous by its echoes, which resembled a band of trumpeters first responding close at hand, and then retreating rapidly toward the coast of France. The siren-echoes on that day had 11 seconds', those of the horn 8 seconds' duration.

In the case of the siren, moreover, the reënforcement of the direct sound by its echo was distinct. About a second after the commencement of the siren-blast, the echo struck in as a new sound. This first echo, therefore, must have been flung back by a body of air not more than 600 or 700 feet in thickness. The few detached clouds visible at the time were many miles away, and could clearly have had nothing to do with the effect.

On the 10th of October, I was again at the Foreland, listening to the echoes, with results similar to those just described. On the 15th I had an opportunity of remarking something new concerning them at Dungeness, where a horn, similar to, though not so powerful as, those at the South Foreland, has been mounted. It rotates automatically through an arc of 210°, halting at four different points on the arc and emitting a blast of 6 seconds' duration, these blasts being separated from each other by intervals of silence of 20 seconds.

The new point observed was this: As the horn rotated the echoes were always returned along the line in which the axis of the horn pointed. Standing either behind or in front of the light-house tower, or closing the eyes so as to exclude all knowledge of the position of the horn, the direction of its axis when it sounded could always be inferred from the direction in which the aërial echoes reached the shore. Not only, therefore, is knowledge of *direction* given by a sound, but it may also be given by the aërial echoes of the sound.

On the 17th of October, at about 5 P. M., the air being perfectly free from clouds, we rowed toward the Foreland, landed, and passed over the sea-weed to the base of the cliff. As I reached the base, the position of the Galatea was such that an echo of astonishing intensity was sent back from her side; it came as if from an independent source of sound established on board the steamer. This echo ceased suddenly, leaving the aërial echoes to die gradually into silence.

At the base of the cliff a series of concurrent observations made the duration of the aërial siren-echoes from 13 to 14 seconds.

Lying on the shingle under a projecting roof of chalk, the somewhat enfeebled diffracted sound reached me, and I was able to hear with great distinctness, about a second after the starting of the siren-blast, the echoes striking in and reënforcing the direct sound. The

first rush of echoed sound was very powerful, and it came, as usual, from a stratum of air 600 or 700 feet in thickness. On again testing the duration of the echoes, it was found to be from 14 to 15 seconds. The perfect clearness of the afternoon caused me to choose it for the examination of the echoes. It was worth remarking that this was our day of longest echoes, and it was also our day of greatest acoustic transparency, this association suggesting that the duration of the echo is a measure of the atmospheric *depths* from which it comes. On no day, it is to be remembered, was the atmosphere free from invisible acoustic clouds; and on this day, and when their presence did not prevent the direct sound from reaching to a distance of 15 or 16 nautical miles, they were able to send us echoes of 15 seconds' duration.

On various occasions, when fully three miles from the shore, the Foreland bearing north, we have had the distinct echoes of the siren sent back to us from the cloudless *southern* air.

To sum up this question of aërial echoes. The siren sounded three blasts a minute, each of 5 seconds' duration. From the number of days and the number of hours per day during which the instrument was in action, we can infer the number of blasts. They reached nearly 20,000. The blasts of the horns exceeded this number, while hundreds of shots were fired from the guns. Whatever might be the state of the weather, cloudy or serene, stormy or calm, the aërial echoes, though varying in strength and duration from day to day, were never absent; and on many days, "under a perfectly clear sky," they reached, in the case of the siren, an astonishing intensity. It is to these air-echoes and not to cloud-echoes, that the rolling of thunder is to be ascribed.

EXPERIMENTAL DEMONSTRATION OF AËRIAL REFLECTION.—Thus far we have dealt in inference merely, for the interception of sound through aërial reflection has never been experimentally demonstrated; and, indeed, according to Arago's observation, which has hitherto held undisputed possession of the scientific field, it does not sensibly exist. But the strength of science consists in verification, and I was anxious to submit the question of aërial reflection to an experimental test. As in most similar cases, it was not the simplest combinations that were first adopted. Two gases of different densities were to be chosen, and I chose carbonic acid and coal gas. With the aid of my skillful assistant, Mr. John Cottrell, a tunnel was formed, across which five-and-twenty layers of carbonic acid were permitted to fall, and five-and-twenty alternate layers of coal-gas to rise. Sound was sent through this tunnel, making fifty passages from medium to medium in its course. These, I thought, would waste in aërial echoes a sensible portion of sound.

To indicate this waste an objective test was found in a gas-flame brought to the verge of flaring. The action of sonorous vibrations on

such a flame was discovered by Professor Le Conte in the United States, who had the sagacity to seize upon the most essential features of the phenomenon. A similar observation was subsequently made by Prof. Barrett, while assistant in the physical laboratory of the Royal Institution; and both he and myself, my present assistant Mr. Cottrell, and Mr. Philip Barry, have succeeded in pushing such flames to an extraordinary degree of sensitiveness. The following brief description of a sensitive flame 24 inches high, issuing from the single orifice of a steatite-burner, is taken from my forthcoming "Lectures on Sound:" "The slightest tap on a distant anvil causes it to fall to 7 inches. When a bunch of keys is shaken, the flame is violently agitated, and emits a loud roar. The dropping of a sixpence into a hand, already containing coin, knocks the flame down. The creaking of boots sets it in violent commotion. The crumpling or tearing of a bit of paper, or the rustle of a silk dress, does the same. Responsive to every tick of a watch held near it, it falls and explodes. The winding up of the watch produces tumult. From a distance of 30 yards we may chirrup to this flame, and cause it to fall and roar. Repeating a passage from the 'Faerie Queene,' the flame sifts and selects the manifold sounds of my voice, noticing some by a slight nod, others by a deeper bow, while to others it responds by violent agitation."

We are now prepared to understand a drawing and description of the apparatus first employed in the demonstration of aërial reflection. I take both drawing and description substantially from an account of the apparatus given by a writer in *Nature*, February 5, 1874:

"A tunnel *t t'* (Fig. 1), 2 inches square, 4 feet 8 inches long, open at both ends, and having a glass front, runs through the box, *a b c d*. The spaces above and below are divided into cells opening into the tunnel by transverse orifices exactly corresponding vertically. Each alternate cell of the upper series—the first, third, fifth, etc.—communicates by a bent tube (*e e e*) with a common upper reservoir (*g*), its counterpart cell in the lower series having a free outlet into the air. In like manner the second, fourth, sixth, etc., of the lower series of cells are connected by bent tubes (*n n n*) with the lower reservoir (*i*), each having its direct passage into the air through the cell immediately above it. The gas-distributors (*g* and *i*) are filled from both ends at the same time, the upper with carbonic-acid gas, the lower with coal-gas, by branches from their respective supply-pipes (*f* and *h*). A well-padded box (*P*) open to the end of the tunnel forms a little cavern, whence the sound-waves are sent forth by an electric bell (dotted in the figure). A few feet from the other end of the tunnel, and in a direct line with it, is a sensitive flame (*k*), provided with a funnel as sound-collector, and guarded from chance currents by a shade.

"The bell was set ringing. The flame, with quick response to

each blow of the hammer, emitted a sort of musical roar, shortening and lengthening as the successive sound-pulses reached it. The gases were then admitted. Twenty-five flat jets of coal-gas ascended from the tubes below, and twenty-five cascades of carbonic acid fell from

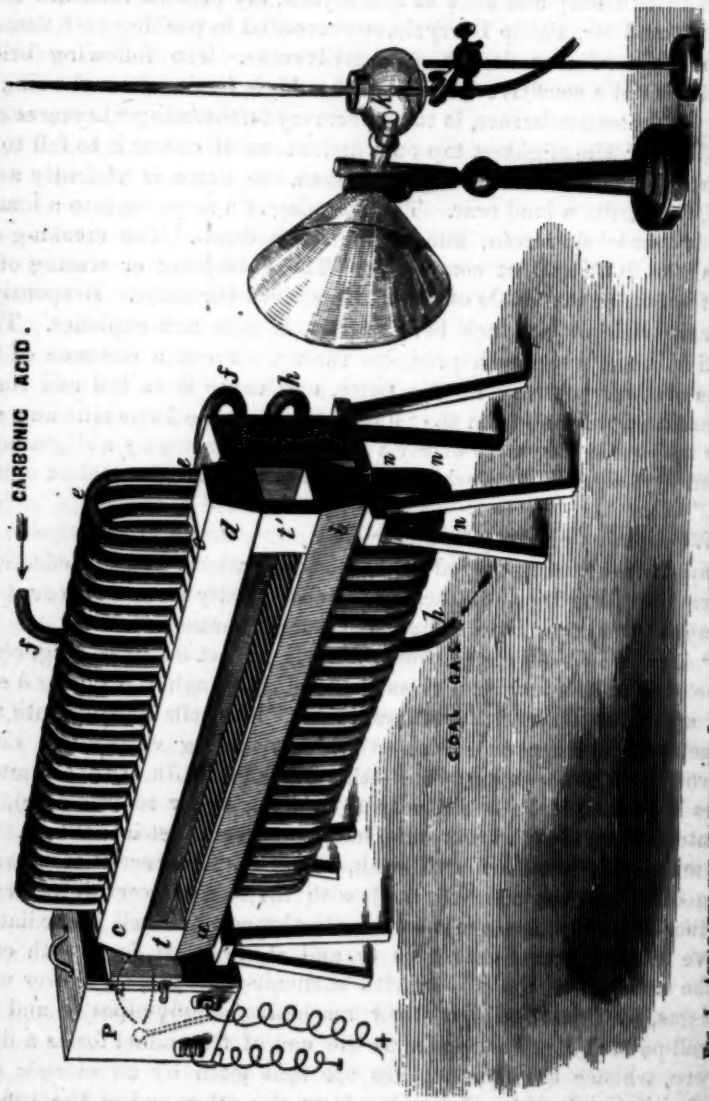

FIG. I.—APPARATUS FOR SHOWING THE INFLUENCE OF A NON-HOMOGENEOUS ATMOSPHERE ON THE TRANSMISSION OF SOUND.

the tubes above. That which was a homogeneous medium, had now fifty limiting surfaces, from each of which a portion of the sound was thrown back. In a few moments these successive reflections became so effective that no sound having sufficient power to affect the flame

could pierce the clear, optically-transparent, but acoustically-opaque atmosphere in the tunnel. So long as the gases continued to flow, the flame remained perfectly tranquil. When the supply was cut off, the gases rapidly diffused into the air. The atmosphere of the tunnel became again homogeneous, and therefore acoustically transparent, and the flame responded to each sound-pulse as before."

Not only do gases of different densities act thus upon sound, but atmospheric air in layers of different temperatures does the same. Across a tunnel resembling *t t'*, Fig. 1, sixty-six platinum wires were stretched, all of them being in metallic connection. The bell, in its padded box, was placed at one end of the tunnel, and the sensitive flame *k*, near its flaring point, at the other. When the bell rang, the flame flared. A current from a strong voltaic battery being sent through the platinum wires, they became heated: layers of warm air rose from them through the tunnel, and immediately the agitation of the flame was stilled. On stopping the current, the agitation recommenced. In this experiment the platinum wires had not reached a red heat. Employing half the number and the same battery, they were raised to a red heat, the action in this case upon the sound-waves being also energetic. Employing one-third of the number of wires, and the same strength of battery, the wires were raised to a white heat. Here, also, the flame was immediately rendered tranquil by the stoppage of the sound.

But not only do gases of different densities, and air of different temperatures, act thus upon sound, but air saturated in different degrees with the vapors of volatile liquids can be shown by experiment to produce the same effect. Into the path pursued by the carbonic acid in our first experiment, a flask, which I have frequently employed to charge air with vapor, was introduced. Through a volatile liquid, partially filling the flask, air was forced into the tunnel *t t'*, which was thus divided into spaces of air saturated with the vapor, and other spaces in the ordinary condition. The action of such a medium upon the sound-waves issuing from the bell is very energetic, instantly reducing the violently-agitated flame to stillness and steadiness. The removal of the heterogeneous medium restores the noisy flaring of the flame.

A few illustrations of the action of non-homogeneous atmospheres produced by the saturation of layers of air with the vapors of volatile liquids may follow here.

Bisulphide of Carbon.—Flame very sensitive, and noisily responsive to the sound. The action of the non-homogeneous atmosphere was prompt and strong, stilling the agitated flame.

Chloroform.—Flame still very sensitive; action similar to the last.

Iodide of Methyl.—Action prompt and energetic.

Amylene.—Very fine action; a short and violently-agitated flame was immediately rendered tall and quiescent.

Sulphuric Ether.—Action prompt and energetic.

The vapor of water at ordinary temperatures is so small in quantity, and so attenuated, that it requires special precautions to bring out its action. But with such precautions it was found competent to reduce to quiescence the sensitive flame.

As the skill and knowledge of the experimenter augment, he is often able to simplify his experimental combinations. Thus, in the present instance, by the suitable arrangement of the source of sound and the sensitive flame, it was found that not only twenty-five layers, but three or four layers of coal-gas and carbonic acid, sufficed to still the agitated flame. Nay, with improved manipulation the action of a single layer of either gas was rendered perfectly sensible. So also as regards heated layers of air, not only were sixty-six or twenty-two heated platinum wires found sufficient, but the heated air from two or three candle-flames, or even from a single flame, or a heated poker, was found perfectly competent to stop the flame's agitation. The same remark applies to vapors. Three or four layers of air saturated with the vapor of a volatile liquid stilled the flame; and, by improved manipulation, the action of a single saturated layer could be rendered sensible. In all these cases, moreover, a small, high-pitched reed might be substituted for the bell.

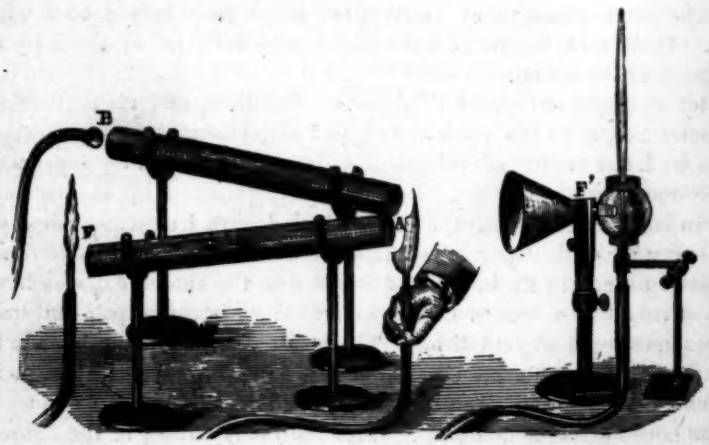

FIG. 2.—APPARATUS FOR ILLUSTRATING THE REFLECTION OF SOUND IN A NON-HOMOGENEOUS ATMOSPHERE.

In the experiments at the South Foreland, not only was it proved that the acoustic clouds stopped the sound, but in the proper position the sounds which had been refused transmission were received by reflection. I wished very much to render this echoed sound evident experimentally, and stated to my assistant that we ought to be able to accomplish this. Mr. Cottrell met my desire by the following beautiful experiment, which has been thus described before the Royal Society:

"A vibrating reed *B* (Fig. 2) was placed so as to send sound-waves

through a tin tube, 38 inches long, and 1¾ inch diameter, in the direction *B A*, the action of the sound being rendered manifest by its causing a sensitive flame placed at *F'* to become violently agitated.

"The invisible heated layer immediately above the luminous portion of an ignited coal-gas flame, issuing from an ordinary bat's-wing burner, was allowed to stream upward across the end *A* of the tin tube. A portion of the sound issuing from the tube was reflected at the limiting surfaces of the heated layer, the part transmitted being now only competent to slightly agitate the sensitive flame at *F'*.

"The heated layer was then placed at such an angle that the reflected portion of the sound was sent through a second tin tube, *A F* (of the same dimensions as *B A*). Its action was rendered visible by causing a second sensitive flame placed at the end of the tube *F* to become violently affected. This *echo* continued active so long as the heated layer intervened; but upon its withdrawal the sensitive flame placed at *F'*, receiving the whole of the direct pulse, became again violently agitated, and at the same moment the sensitive flame at *F*, ceasing to be affected by the echo, resumed its former tranquillity.

"Exactly the same action takes place when the luminous portion of a gas-flame is made the reflecting layer, but in the experiments above described the invisible layer above the flame only was used. By proper adjustment of the pressure of gas, the flame at *F'* can be rendered so moderately sensitive to the direct sound-wave that the portion transmitted through the reflecting layer shall be incompetent to affect the flame. Then by the introduction and withdrawal of the bat's-wing flame the two sensitive flames can be rendered alternately quiescent and strongly agitated.

"An illustration is here afforded of the perfect analogy between light and sound; for if a beam of light be projected from *B* to *F'*, and a plate of glass be introduced at *A* in the exact position of the reflecting layer of gas, the beam will be divided, one portion being reflected in the direction *A F*, and the other portion transmitted through the glass toward *F'*, exactly as the sound-wave is divided into a reflected and transmitted portion by the layer of heated gas or flame."

Thus far, therefore, we have placed our subject in the firm grasp of experiment; nor shall we find this test failing us further on.—*Contemporary Review.*

THE MENTAL ASPECTS OF ORDINARY DISEASE.[1]

By J. MILNER FOTHERGILL, M. D.,
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SO long as the mind was regarded as something separated from the body, or only united to it by feeble ties, bodily conditions could have nothing to do with mental phenomena—insanity was a disease of the soul. The monk, standing over a miserable lunatic chained to a staple in the wall, and flogging him in order to make him cast his devil out, was a logical outcome of this hypothesis. The union of psychology and physiology is the closing of the circuit, in one direction, of the pursuit after knowledge, and marks the initiation of a rational comprehension of the mind and of its relation to corporeal conditions. How such mistaken ideas of the word *melancholia*, as those entertained by the monk in his capacity of physician for diseases of the mind, could have attained their sway in the face of the maxim *mens sana in corpore sano*, only becomes intelligible when we remember the ignorance, the superstitious prejudices, the contempt for knowledge of the natural man, which found their highest expression during the monkish supremacy of the dark ages. Slowly but surely was the emancipation of the intellect from the fetters of priestly tyranny achieved. The days of the minor Trinity—the soul, the mind, and the body—are numbered; the advent of a physiological psychology is at hand. That insanity which was regarded as an indication of some disease of the soul, in whose production the body had no share, is now known to be linked with appreciable pathological changes, and in many instances is amenable to physical remedial agents. Thought is the product of the cells of the gray matter of the brain—the result of a change of form in inorganic matter taken into the system as food, of which acids and other products of oxidation, of retrograde tissue-metamorphosis, are the waste.

Such being the case, it is obvious, then, that bodily conditions will affect the nutrition of the brain, or rather of the cerebral cells, and so modify their products. It is not necessary to go into the more pronounced conditions called insanity for the evidences of such influence; they are to be found in the varying mental attitudes of common life. It is true, however, that the study of the more marked cases furnished by insanity, with their deeper shadows and clearer definitions, is the best preparation for the proper recognition and discrimination of the finer shades, the slighter changes, which exist among the sane. More especially is this the case in attempting to analyze the varying emotions. At one time all looks bright, cheerful, and encouraging; at another, the same prospect looks cheerless and tinted with despair.

[1] Condensed from the *Journal of Mental Science*.

This change depends upon physical conditions, and a more pronounced physical state not only involves the emotional centres, but implicates the intellectual processes. Thus, a slight amount of bile in the blood, or an excess of renal products, may depress a man with hopeless despair or drive him into paroxysms of violent passion. The delirium of fever is a familiar instance of the influence exercised by passing bodily conditions upon the brain and its product—thought.

When the nutrition of the brain is good, we experience an agreeable sense of well-being, which shows itself distinctly in after-dinner geniality. When the nutrition is imperfect, or the arterial blood is of abnormal composition, the consequences are a mixture of irritability and bad temper, blended with depression. We are all familiar with the crossness of the hungry man; when fasting, crossness is interchangeable with hunger—is often its substitute, and forms a contrast with the amiability of repletion. Especially is this irritability seen in those whose digestive powers are weak. A similar irritability is the ordinary mental attitude of convalescence from acute disease, and either precedes or runs into and coexists with the keen appetite usually found at that time. They are linked together by something more positive than coincidence.

The dependence of modifications of the functional activity of the cerebral cells upon other corporeal conditions than changes in the blood is now well recognized. There are communicating fibres by which the brain receives impressions of varying character from different organs. An impression coming in from some far-away point stimulates or inhibits the action of the cerebral cells. So strong may be the impression that actual insanity may result, as in the case, related by Schroeder van der Kolk, of a lady who became insane whenever her womb became displaced, and sane again as soon as it was returned to its place.

The effect of several morbid states is to stimulate the brain into greater activity. A non-medical but most acute observer and able writer[1] says:

"It seems even that bodily pain and disease are not only compatible with, but may directly contribute to, the loftiest efforts of the intellect. They sometimes positively enhance its powers. The effect of some disorders and of certain sorts of pain upon the nerves is to produce a cerebral excitation; and the stimulus thus communicated to the material organ of thought renders it for the time capable of unusual effort. Men under the stirring influence of severe pain are capable of a degree of imaginative and ratiocinative brilliancy which astonishes themselves and all who have known them only in ordinary moods of comfort. Torpid faculties become vigorous and sparkling. Forgotten knowledge is recovered. Marvelous gleams of insight are vouchsafed them. The wonderful eloquence of Robert Hall was doubtless greatly owing to the stimulating influence of a terrible spinal malady. Dr. Conolly mentions a gentleman whose mental faculties never reached their full power except under the irritation of a blister. Ab-

[1] "The Enigmas of Life," by W. R. Greg.

normal and unsound conditions of the bodily organs sometimes give us glimpses of mental powers and possibilities far exceeding any thing of which ordinary health is capable. The phenomena of some nervous disorders are positive revelations, and most startling ones, of what the human intellect, disengaged from matter or under favorable material conditions, might achieve and learn."

When Greg talks of intellect disengaged from matter, he is led away into poetical metaphor, which is, however, allowable in one who is not a professed physiologist.

We are all familiar with the effects of alcohol upon the intellectual powers. A gentleman mentioned by Dr. Willis, who was liable to periodical attacks of insanity, said that he expected the paroxysms with impatience, because, during them, he enjoyed a high degree of pleasure. "Every thing appeared easy to me. No obstacles presented themselves either in theory or practice. My memory suddenly acquired a singular degree of perfection. Long passages of Latin authors occurred to my mind. In general, I have great difficulty in finding rhythmical terminations, but then I could write verse with as great facility as prose."

There are two distinct physical conditions under which the intellect seems to possess a power and a brilliancy much exceeding the normal standard. These two conditions are: 1. The initial or pretubercular stage of pulmonary phthisis; and, 2. The condition of chronic gout. Whatever difference of opinion may exist as to the explanation of the cause of this high state of mental activity, there can be none as to the fact. There is, as it were, almost an aureole of intellectual light around the heads of those who are about to enter the fated pathway of pulmonary tuberculosis. To what it is due, it is difficult to say. One factor may be some accession of arterial blood to the cerebral cells in excess of the normal flow. We know that there are usually an accelerated pulse-rate and a heightened temperament in such cases. There may be some nerve-communication between the lungs and the vaso-motor nerves of the cerebral vessels, of which we are as yet but dimly conscious, which may some day explain the matter to us. As to the intellectual power of the gouty, there is less difficulty in explaining it. In the first place, the blood of the gouty is highly charged with nitrogenized matter. Carpenter has pointed out ("Human Physiology," sec. 62) how desirable a nitrogenized diet is for the evolution of nerve-force, while Liebig dilates upon the effect of food upon the disposition, in his well-known "Letters on Chemistry." M. Metz, of Mattray, found the value of a liberal dietary in giving strength of will to irresolute boys in his reformatory. An excess of nitrogen in the system, and especially in the blood, acts as a stimulant to the brain-cells in the case of the gouty. This, however, is but half of the matter; there is an equally, or even more important factor, in the condition of the circulation.

Careful investigation has demonstrated to us the state of the cir-

culation in chronic renal inadequacy. There is usually decided hypertrophy of the left ventricle, and a high arterial tension, originating in a contracted condition of the terminal arteries. As a consequence of this tension, the blood-pressure on the brain is well sustained; and a free supply of arterial blood, rendered perhaps more than ordinarily stimulating by the presence of nitrogen in excess, evokes a heightened activity of the cerebral cells. Simple hypertrophy of the heart is mostly found in the subjects of chronic renal changes. That there is a certain explosiveness in the gouty, together with much mental activity, is simply a clinical fact. The excess of nitrogen in the blood stands in a suggestive relationship to the explosive irritability, while the high blood-pressure is evidently causally related to the heightened mental activity. The two factors requisite for rapid evolution and discharge of force by the cerebral cells are found together under the above-named combination. If the changes in the circulation are imperfect, and the blood-pressure is but low, or even normal, the gouty person is not mentally inactive, but is despondent.

Bichat observed that the length of the neck exercises an influence over the mental activity of the individual. Persons with short necks have a better sustained power of work than those who have long necks, or, in other words, other things being equal, the brain, which is superimposed on a short neck, has an advantage over the brain fed by a long carotid artery. Van der Kolk is in agreement with Bichat upon this point. An extensive series of observations inclines me to agree with them.

Van der Kolk also quotes from Haller the observation that rickety children have generally large heads, and possess quick perceptive faculties; and that the blood-vessels of their heads are distinguished for their large calibre. Certainly such children are commonly very precocious. There is a point, however, in relation to this matter which must not be overlooked. Rickety children are usually of scrofulous tendency, and in the scrofulous there is usually an excess of lithates in the blood, which will not be without the ordinary effect exercised by nitrogen on the brain. The great Dutchman also states, "It is a known fact that hunchbacked individuals, in whom the blood flows more quickly and strongly toward the brain, are remarkable for vivacity of spirit." It will not do, in this consideration, to leave out of the question the possibility of a mental factor; that the physical deformity turns the mind of the individual toward mental cultivation as a compensation for bodily defects. Granting this, we must also remember that mere will and perseverance exercise a limited influence, and only permit a brain to make the most of itself. What exists there potentially, it may draw out into actual manifestation; but with this the power of the will ceases. An effort of the will may and does dilate the blood-vessels of the brain, and permits larger circulation through it; but the general blood-pressure in the systematic vessels

is an important matter in sustaining the intercranial flow. If the general blood-pressure in the vessels of the head and neck is high and well maintained, then a brain can work up to a much higher power, just as a steam-engine may be worked up to a higher pressure, and so become actually more powerful.

While we recognize the fact that mental conditions are causally associated with the amount of the blood-supply, indeed to a great extent rest upon it, it must not be supposed that I wish to under-estimate the importance of the condition of the cerebral cells themselves, either as to their inherited peculiarities, or as to the conditions produced by the experience of the individual. Such consideration is, however, without the sphere of the present paper, which deals with cerebral manifestations in relation to ordinary disease, and not with those ailments which belong to the province of the alienist physician. To one form of disorder of the cerebral cells alone may reference be made here, and that is as to the effects of mental over-strain. Brain-tissue can be developed by exercise, and worn out by overwork. When this latter condition has been induced, there exists that irritability which forms part of the early stage of the exhaustion of nerve-matter. In all overtried brains there is much irritability and tendency to manifest what we term temper. This fact we learn in time about the individual, but we are somewhat slow to recognize it in the abstract. It is socially desirable and important that such recognition be more general.

In considering the associations existing between cerebral manifestations and certain conditions of the organism, and the effect exercised by the latter upon the former, it is important to bear in mind that the brain is divided into two vascular areas: 1. The anterior, fed by the internal carotids; and, 2. The posterior, fed by the basilar artery; nor is the amount of inosculation in the intercranial circulation such as would allow vicarious action to make good a deficiency caused by an interference with the direct supply of either area. These two vascular areas contain brain-cells with different properties and functions. There is much reason to believe that the emotions and systematic sensations lie on the posterior area; and that the intellectual and motor powers, together with general peripheral sensations, lie on the anterior area. In other words, the posterior area is associated with the organic processes of the system; the anterior with the animal life—with the relation of the organism to its surroundings. The vaso-motor nerves of these two areas are differently derived. The nerves of the cerebral arteries spring from the lower ganglion of the great sympathetic nerve in the neck, into which run the fibres ascending from the abdomen; while the carotid arteries derive their vaso-motor supply from the middle and upper ganglia. Thus we can see how the emotions sympathize with the organic processes, especially those located in the abdomen, and so can see melancholia in a new

light; can comprehend how mental depression may wait upon and depart with abdominal disturbance. The disturbance does not extend to the intellectual processes; the emotions alone are involved. The sense of well-being, or of discomfort, depending upon systemic conditions, tells of the relation existing between the emotions and the organic processes; and the nerve-tracks just described enable us to comprehend the subject more clearly.

There is an interesting point connected with this division of the cerebral hemispheres, and the functions of each division, to which we may advert. It is the association existing between states of emotional depression and abdominal disease, and the comparative absence of such depression in affections of the lungs. Marshall Hall writes: "The temper of the patient is singularly modified by different disorders and diseases. The state of despondency in cases of indigestion forms a remarkable contrast with that of hopefulness in phthisis pulmonalis, and other serious organic diseases."

In diseases of the lungs, the condition of depression is rarely present, and, when so present, is possibly due to some abdominal complication; though, of course, some of the existing depression may be fairly attributed to the anxiety naturally arising from an intelligent comprehension of the danger impending. In tuberculosis of the lung there is commonly such an emotional attitude in the patient as has earned for itself the designation of *spes phthisica*. Here the hopefulness is as irrational as is the depression of some other affections. The consumptive patient just dropping into the grave will indulge in plans stretching far into the future, ignoring his real condition, and the impossibility of any-such survival as he is calculating upon. It is a curious yet a familiar state. Hope seems to rise above the intelligence, just as in certain abdominal diseases there is a depression which defies its corrections. The intellect is not equal to finding the true bearings or of correcting the exalted emotional centres. In curious relation to these conditions stand well-known differences of the pulse. In chest-diseases the pulse is usually full, sometimes bounding; in abdominal disease it is small and often thready. The pulse of pneumonia and the pulse of peritonitis are distinctly dissimilar and contrast with each other. It is well known that there is much more tendency to collapse in abdominal than in thoracic disease; taking the conditions of the pulse together with the emotional attitudes of these affections, the synthesis is unavoidable that some effect is produced by the tubercular disease in the lungs upon the emotional centres as opposite to the effect of abdominal disease as are the varied effects upon the pulse; and further that the result is probably produced through the circulation. The explanation which is shadowed out, for it really does not amount to more, is that abdominal disease causes a depletion of the emotional centres—of which depression is the outward indication—while phthisis leads to a plethoric state associated with exalted emo-

tional conditions. In either case the intellectual and volitional centres appear unequal to the task of maintaining the balance which normally exists. As a matter of fact, there are certain mental attitudes found in some diseases which are so regularly present, so well marked and pronounced, that they may fairly be included as a part of the rational symptoms. So commonly is mental depression found along with biliary disturbance that the name *melancholia* was given to these conditions of mental gloom; and modern observation is but establishing the propriety of the term.

Allied in essence to melancholia is the panphobia, or "low spirits," common to women generally, but especially found in the *habitués* of our out-patients' rooms. It is the cry of the suffering brain for better nutrition, for a more liberal supply of arterial blood. There is much emotional mobility and the patient is easily moved to a flood of tears by the slightest exciting cause. Under different circumstances relief from the depression is sought in alcohol, and this is the most depraved, the most hopeless, and the deadliest of all forms of habitual intoxication, the more hopeless from its being based on physical conditions; or it stimulates the spinster and the widow to a pseudo-religious existence, where the religious fervor is the measure of the cravings of the ungratified physiological aspirations.

We do not consider, perhaps, because the subject is repugnant to us, how much our psychical attitude, even to religious, the highest of all thought, is based upon conditions of the body; that body which theologians of the old school denominate vile, which they would trample under foot, nay, even ignore, yet which is reigning supreme and dominating and directing them in their highest aspirations. What a terrible revelation this gives us of the psychological attitude of the monk, who thought to subdue his inborn passions by scourgings, fastings, sleeplessness, and religious exercises, when all the while he was the victim of their thwarted and riotous activity as they crowded his mental horizon with gloomy or sensual images and presented a future of everlasting damnation to his superstitious vision!

Another form of psychical disturbance is furnished by the perturbations termed hysterical attacks, and which usually occur under circumstances of repressed passion. There are an excitability and mobility about the person which tell how the emotional centres are quivering and vibrating under the tension to which they are subjected, and the emotional oscillations, from weeping to laughing, indicate that the emotions are no longer under the control of the volitional centres. This loss of equilibrium becomes more marked when any disturbance of the bodily health leaves the organism at the mercy of these emotional storms. Hysterical attacks are generally explosive discharges of the emotional centres, as epilepsy is of the motor or mania transitoria (demoniacal possession) is of the volitional centres. They all resemble the "blowing of the engine" when it

has stood still some time and the steam-pressure is becoming dangerously high.

Much mental instability is found among sufferers from chronic heart-disease, and many and pronounced are the mental modifications induced. In one case, I remember well, a very old patient, who was the subject of aortic obstruction, became remarkably polite when the results of the cardiac lesion were very marked, a mental attitude far removed from that which he habitually assumed. Usually a totally opposite character of change is produced, and the effect is to cause the mental operations to be imperfect, unsustained and unequal, while there are present suspicion, doubtfulness, vacillation, and caprice. Indeed, the mental change is usually for the worse; and along with intellectual enfeeblement there is an alteration of the emotional products which we have seen to be allied with cerebral depletion. The false and morbid feelings which are the products of imperfectly nourished cerebral centres bear the same relation to normal thought that Emerson says evil does to good—it is good in the making; and more perfect elaboration of the outcomes of emotional centres would give us healthy instead of morbid feeling.

The mental attitude of sufferers from heart-disease is usually one of caprice, unsustained volition, together with suspiciousness and groundless fear—imperfect emotional products.

Another marked mental attitude is furnished by those who suffer from gout in any of its forms, for suppressed gout is the most protean of diseases. We have already seen how gout-poison stimulates the intellect in the earlier stages of granular kidney; what we may now consider is the mental modification produced by advanced disease. There is a mixture of explosiveness, the gouty temper, with suspicion and depression, the consequences of spasm of the intra-cranial arteries. Instead of the well-sustained blood-pressure of the early stages with the stimulant gout-poison irritating the cerebral cells into activity, we have the stimulant quality of the blood together with an impaired and insufficient supply. The resultant product is a blended compound of irritability and suspicion, bad temper and anxiety, the latter all the more aggravating from a consciousness that it is not mere illusion, but an emotional hallucination.

Such individuals are the terror of their dependents and the *bêtes noires* of their domestics. There is such a villainous state of temper, at times ascending to ferocity, that the person becomes simply intolerable; the unfortunate sufferers themselves being still further tortured by the haunting impression that they are utterly unreasonable, and that their attitude does not arise from any provocation from without, but that it takes its origin in some abnormal condition existing within. In one case well known to me the sufferer sought relief in religious exercises, in resort to her Bible and to prayer—it is needless to say without the desired result. What she needed was not spiritual

discipline, not correction of the mind through the soul's portals, for she was a truly good and high-minded woman, but a remedying of the bodily condition on which the mental state causally depended. As a matter of fact, well-directed treatment produced a restoration of the normal feelings and emotions which all the spiritual exercises had signally failed to achieve.

Another peculiar and fairly-pronounced mental attitude is that furnished by the victim of cancer. The form assumed here is that of sullen and defiant submission to the inevitable. There is rarely any active and positive attempt made by the sufferers themselves to avert their doom. There is, as it were, a volitional control exercised over the impulses, which is marked, and the sufferer submits to a grip he sees no chance of eluding. But it must not be supposed that there is an abolition of the instinct of self-preservation; it is merely subordinated. That this is the actual attitude is shown by the fact that when the mind is wandering at the last, especially in gastric cancer, which interferes so much with nutrition, the patients in their delirium commonly ask for a knife in order to excise the hostile malignant growth which is involving their existence.

The mental attitude of pyæmia (alteration of the blood by pus) is, again, quite distinct from any of the foregoing. It is that of absolute indifference. From the first long shivering fit which marks the initiation of the fateful disease, the mental attitude is usually that of imperturbable indifference. Marked by utter unconcern as to the course of the disease, it contrasts very strikingly with the ill-founded hopefulness of hectic, and especially of pulmonary phthisis. Of course it is not asserted that the mental attitudes described are invariable and ever present in the different diseases; only that they are so common that they cannot be regarded as mere coincidences.

In diabetes mellitus, too, there is a condition of mental languor and depression, which is as marked as the muscular lethargy and lassitude manifested by sufferers from that affection, and which often precedes those physical symptoms which we are too much inclined to regard as the chief indications of that disease.

The condition of the mind in the delirium of fever is a subject of much interest, albeit it is surrounded by many difficulties. The great one is that people at large are too much accustomed and inclined to regard delirium as aimless, objectless mental action—a chaos of broken ideas and unconnected thoughts, or an uncovering of the sewers of the mind, the revealing of secrets not always innocent. The first is the way in which they regard it in others, the latter, the form in which they apprehend it in themselves, so that there is not given to it that intelligent attention the subject deserves; nor are those immediately and constantly around the delirious patient likely to possess a calm, dispassionate, and competent capacity to attend to what is going on in his mind, so far as it finds expression in words. The anxious

relatives and the overworked paid nurse do not possess the qualities requisite for correct observation of this complex condition, even if they could be induced to make the nature of the delirium the object of their attention. The impressions remaining on my own mind of my thoughts during a pretty sharp and well-sustained delirium, due to a grave attack of scarlatina, are that there were two leading ideas dominant in my mind: the one in relation to my surroundings, the other in relation to my aims and my occupation. The first, though less predominant, were distinctly the more vivid impressions, and they were not only very unpleasant, but their remembrance is ineffaceable. They arose chiefly through the weakened senses, especially the sense of sight. The bedroom I had occupied for years had been rearranged to adapt it to the necessities of a sick-room, and, on waking, the eye did not immediately recognize it. This at once gave a direction to the wandering thoughts, and the leading idea was to get home. The opposition offered to my attempt to escape seemed to me so unjust and improper that violence must be resorted to in order to overcome it, and then followed a wild, delirious struggle, terminating in complete exhaustion. This opposition engendered a strong feeling of personal dislike, blended with suspicion toward those around me, and their kind attentions were interpreted by the reeling brain as unjustifiable interference with natural and intelligible wishes. The remembrance of the feeling of dislike thus originated remains sufficiently strong to occasionally tint the thought yet; for the residua remaining in the cerebral cells exercise an influence on the thought-currents when passing over them.

The other source of disturbance was the influence of the lines of thought which were predominant in the mind ordinarily. These formed the chief subject of my wanderings during the delirious period. At times, the impression that certain patients ought to be seen would become so vivid that I desired to be dressed in order to pay the required visits. Opposition to this, of course, aroused indignation and resentment, and strengthened the suspicions already excited by the restraint exercised to prevent, as I imagined, my returning home.

The remembrance of the condition is still sufficiently vivid to explain the mental attitude of those whose intellect is waning, either from dotage or from a like condition of brain-failure inaugurated by acute disease. Why their relations, who attempt to contradict or to control them—not always with the happiest tact—are objects of dislike and suspicion, is intelligible enough; as also why attendants who humor and cajole them are thereby endowed with a potential, undue influence. The brain, becoming less and less functionally capable, is more and more unequal to the correction of its ill-founded or unjust dislike.

There is nothing monstrous in the mental products; there is just that deviation from the rule that might be anticipated when the func-

tional activity is modified by structural changes. There is not a new line of thought instituted, leading in opposite directions to the normal thought, but a misdirection of the ordinary mental processes. There is, however, a certain amount of illusion which, when pronounced, or when the effect upon the brain-cells is such as to cause an evolution of distinctly-erroneous thought, or actual hallucinations, indicates that the frontier of sanity is crossed.

Such considerations will enable us to observe and to comprehend that initiatory stage of mental impairment which precedes obvious and well-marked dotage. The earlier stages, the lighter shades of mental failure, of waning brain-power, are distinct enough to the trained eye, long before those more obvious changes are reached which are recognized by the untrained observer. Such mental changes are commonly found in those undergoing degenerative physical changes, not only in the very aged, but in those passing into premature decay; in fact, mental impairment and decay are but the evidences or outcomes of the implications of brain-tissue in the general degeneration. We are, of course, most familiar with such changes in the very old, in whom we regard them as almost normal. The mental grasp is imperfect and illusive; petulance and caprice are the characteristics, especially of those in whom the intellect was never very strong. Their intellectual vision is deceptive and untrustworthy. A dim consciousness of some such change obtains in the mind, and makes them deeply suspicious and extremely susceptible, and ready to take offense at the slightest indication by others of a knowledge of their growing incapacity. Nor can we feel surprised at this sensitive suspiciousness. Mental decay cannot be a pleasant matter for those undergoing it, and no wonder they are excessively jealous of any alteration of manner or attitude.

A similar condition of enfeeblement, combined with excessive jealousy and deep-rooted suspicion, is furnished by those who have anticipated the normal time of senile decay by habits of drunkenness. The man who is beginning to yield under persistent alcoholization, and who feels that his powers are giving way, is generally suspicious and jealous, if not actually malicious. The intellect undergoing premature degeneracy is more readily and easily provoked than is that of a person entering normal dotage; while there is often coexistent a certain amount of spasmodic vigor of temporary active irritability. Such persons are simply dangerous to those dependent upon them, and not to be trusted—their mischievousness being only restrained by their incapacity to execute or put in force their malicious designs.

There are two other mental attitudes which are not directly associated with bodily disease, but which exercise so distinct an influence over physical conditions, especially in sickness, that they may not improperly be considered here, though not quite falling within the scope of this paper. One is that condition of mental impairment in which

the intellect becomes servile. It is usually shown by elderly people, who are utterly dependent on the bounty, and therefore on the will, of others. That such a condition of helpless submission should obtain under these circumstances, and especially in women, is readily to be conceived. The utter helplessness and entire abolition of self-confidence so induced have a most pernicious effect upon the mental processes; the intellect becomes restricted, and solely directed toward observing and accommodating themselves to the varying moods and passing caprices of those upon whom they depend. Chameleon-like, they change color with every new shade of opinion with which they come in contact, until at last they lose their individuality altogether. The mental condition of these unhappy beings is pitiable in the extreme; there is a paralysis of all volition. "Everywhere and ever, to be weak is to be miserable," and cunning is the only refuge of the feeble. This mental attitude is a matter of moment, and needs recognition when such persons become objects of medical care, and must be included in the formation of a prognosis; the mental instability and tendency to oscillate being very troublesome, and interfering with the working of every systematic plan. Under totally different circumstances, a similar brain-starvation is manifested by those persons who voluntarily cultivate a mental predisposition to religio-melancholia. Their aspirations, originally directed by their surroundings, are ultimately guided by an artificial substitute for the will which they in time develop. It is the psychical side of a question of which the physical side has been discussed before. The intellectual imbecility eventually reached under these circumstances is something pitiable. The intellect is prostrated before an irritable conscience, rendered morbidly sensitive by persistent self-introspection fostered by vigils, developed by fasting, and misdirected by a cramped and imperfect education. The influence exercised by this condition of intellectual enfeeblement also becomes practically important when any line of treatment has to be pursued, and especially so in that complex combination of dyspepsia and constipation to which such persons are so subject. With such persons, the plainest and simplest truths of the natural man seem to take on the aspect of most abstruse and difficult problems; the fullest explanations and clearest directions are insufficient to enable their enfeebled intellects to grasp the subject. Superstitious credulity displaces reasonable belief, and enervates the mind until it can evolve no healthful thought; the morbid activity of pseudo-religious sentiments induces such a palsy of the moral nature, that it becomes incapable of rising in revolt or of seeking to escape its intellectual thraldom.

In those who are exhausted and worn out by toil, either mental or physical, or both combined, but usually by strenuous bodily labor, united with petty mental anxieties and fretting, wearing thought, a condition of brain-degeneration is produced, which exercises much

effect upon the progress of any ailment requiring medical treatment. This class of cases occupies a sort of disputable ground, a border territory which scarcely permits of their being included in hand-books of insanity, nor yet in the ordinary systems of medicine. They are considered here among the aspects—not as outcomes of disease, as are the mental attitudes described in the earlier divisions of this paper, but rather as mental conditions, not normal nor yet insane, which exercise much influence over the progress and course of ordinary ailments.

Finally, there is a condition of temporary, evanescent brain-impairment, which is produced by acute disease, and especially by severe attacks of fever. The mental faculties are usually somewhat impaired by severe attacks of typhoid fever, and soldiers, after recovery from such, are not put on sentry duty for months, as they are pretty certain to forget the watchword and countersign. At other times, more marked impressions are made; certain acquirements are entirely lost, or the mind may even become a smoothed tablet. Many curious instances of such effects are furnished by Abercrombie, in his well-known work, "The Intellectual Powers," and by Carpenter, in his recent work on "Mental Physiology." Commonly enough, this passing condition of brain-impairment is followed by an accession of mental vigor and a condition of intellectual activity which remain permanently and exercise an excellent influence over the after-life of the individual.

The relations of body and mind are becoming much more comprehensible and better understood since Science has shaken off the incubus of theological teaching as to the severance of soul and body; that baneful psychology is now thoroughly undermined; the erroneous and mischievous superstructure is cracking and gaping on every side, and ere long the ground occupied by a crumbling ruin will be covered by a gradually growing erection, based on a foundation of facts, and reared by an expanding intelligence.

BIOLOGY FOR YOUNG BEGINNERS.[1]

By SARAH HACKETT STEVENSON.

II.

IN the chimney-corner by the kitchen-fire stood a quaint stone jar that every winter morning bubbled over with the light, gray foam of buckwheat-cakes. While our "mouths watered," our minds wondered—wondered at the magic by which so many cakes were made out of so little flour. We believed there were fairies in the yeast; but it was only the other day that I succeeded in finding these fairies, and I want to tell you how you may find them too.

[1] From "Boys and Girls in Biology," in the press of D. Appleton & Co.

To begin with, you must have a spoonful or two of yeast to look at while I talk. You will probably notice first a number of bubbles, like soap-bubbles; but, instead of common air, the yeast-bubbles contain a gas made by the yeast—carbonic-acid gas. Next you will notice the brownish color of the yeast; it grows thicker and muddy, and after an hour or so begins to rise. This rising the chemists call fermentation; biologists call it growing. The spoonful has become a cupful. The yeast is really alive, and it is one of the simplest forms of life. In studying biology, then, or the science of life, we begin at what seems the beginning.

All that I have described you can see with your own eyes; but now I must tell you something about the yeast which you could never find out with your eyes alone. With the aid of the microscope, a great many little solid bodies are seen floating about in it. Sometimes they are found alone, but most frequently in groups (Figs. 1–5),

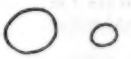

FIG. 1.—ROUND CELLS.

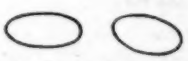

FIG. 2.—LEMON-SHAPED CELLS.

FIG. 3.—OUTER AND INNER SURFACE OF SAC.

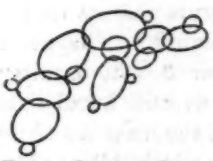

FIG. 4.—GROUP OF CELLS.

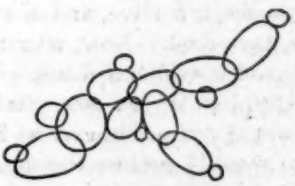

FIG. 5.—GROUP OF CELLS.

and each one is about $\frac{1}{1000}$ of an inch in size. Though they are solid, yet we can see through them, and they are always round (Fig. 1), some of them not quite as round as a ball, more like a lemon (Fig. 2), but none of them are square or flat. The cover of each one is double (Fig. 3), that is, it has an outside and an inside. Under the microscope, these two surfaces look like two round lines, one within the other (Fig. 6). Inside these lines is something which looks like little grains (Fig. 7); and this whole cover, with all that is inside of

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.—YEAST-CELL, OR TORULA.
a, Jelly, or Protoplasm;
b, Thin Space, or Vacuole.

it, is called a cell. Now you must learn of what these cells are made. First there is the outside part, which is like a bag or sac. This bag is tough and solid, and is full of a jelly-like substance, which is thick

and brownish, next the wall of the bag, but thinner and more transparent toward the centre (Fig. 8). This jelly (*a*) is called protoplasm, and the thin space (*b*) in the centre is an air-cell or vacuole (Fig. 9). If you color the yeast-cells, you can see the different parts much better. A drop of magenta will pass right through the sac without staining it at all. The cell-jelly, or protoplasm, will be quite red, and the vacuole will not be colored, though it may look pinkish, because you see it through a layer of the protoplasm (Figs. 10, 11). Now, if the cell were all made of the same material, it would probably all be colored by the magenta.

These cells are called torulæ—a single one is a torula. The word means a little knobby swelling. You will soon see how it comes to

FIG. 10.—Jelly stained, and the Sac clear.

FIG. 11.—BROKEN CELL. Sac clear, Jelly stained.

have this name. If you have followed me carefully, better still if you have seen it all for yourselves under the microscope, you know that the torulæ are alive, and that they grow. Every thing that grows must have food. Now, whence does the torula get its food? From the liquid in which it floats. What is this liquid? The greater part is water, but if you sow yeast in pure water it will hardly grow at all; but if you put in ever so little sugar, it will froth and bubble considerably. If besides the sugar you give it the least bit of ammonia, magnesia, lime, and potash,[1] it will thrive splendidly. The torula takes in this food, and churns it up into that "elixir of life" or protein, woody cells or cellulose, and fat. Then, if you watch carefully, you will see a whole lot of little buds coming out around the edges of the wall (Fig. 12); hence the torula is really a little knobby swelling. Some of the buds have other buds at their edges; all these buds are the little baby-torulæ. By-and-by they break away from the old mother-torula, but they always pay visits back and forth, and sometimes build their houses right next the parental roof in clusters (Fig. 13); at other times they build in long rows, like a chain or a string of beads (Fig. 14). Of this you may be sure, every torula has a mother. People have been trying to prove for two hundred years or more that these little specks of life can make themselves. Some time

[1] PASTEUR'S FLUID.

	Parts.		Parts.
Potassium phosphate	20	Cane-sugar	1,500
Calcium phosphate	2	Water	8,376
Magnesium sulphate	2		
Ammonium tartrate	100		10,000

I will tell you how you can prove that this is not true. These little torulæ float about in the air, or sleep in any dry place, never showing that they are alive till they are planted in some nest or nidus. When the cook dries her yeast-cakes, she puts all the little torulæ to sleep, and there they go into winter quarters, or hibernate in their cells, like the bears in their caves.

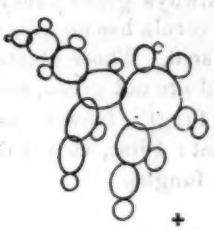

FIG. 12.—CELL AND ITS BUDS.

FIG. 13.—THE BABY TORULÆ GROUPED AROUND THEIR MOTHER.

FIG. 14.—CELLS LINKED TOGETHER IN CHAINS.

There is still another appearance of yeast. Let your cup of yeast stand long enough, and do not add any more sugar or water to it, you will find that the bubbling or fermentation stops, the torulæ settle to the bottom, and the fluid comes to the top. This fluid has a strong or biting instead of a sweet taste, like the fluid into which you first placed the yeast. The fermentation has changed its nature—the fairy torulæ with their magic wands have turned the sugar into carbonic acid, alcohol, glycerine, and succinic acid. These are called the products of fermentation. The carbonic acid, you know, passed off through the bubbles, the other products are still in the fluid. A little of this fluid will make you merry; if you take much of it, you will become intoxicated. This is due to the alcohol, and the value of yeast depends upon its power to make alcohol. You may know that the fluid is alcohol if, when you touch it with a lighted match, it burns with a blue flame.

Now, I have told you the torula grows—it has life; but how does it grow—as a mineral, a vegetable, or an animal? The mineral grows larger and larger by additions made to its outside. This is called growth by accretion. But the torula or yeast-cell grows by taking in new substance in among the particles of its old substance, and this kind of growth is called by a long name—intussusception. This is one of the reasons why it is not a mineral. Is it an animal? The line that divides the animal from the vegetable kingdom is not very well marked, but there are two reasons why the torula is not an animal. In the first place, its jelly or protoplasm is shut up in a close sac, but the protoplasm-jelly of animal cells forms a wall of itself. In the second place, the torula can make its own food or protein out of the raw material it finds in the liquid, while the animal cells seem to have no such power; they must have their protein already made, and

their work is to destroy it. So, if the torula is not a mineral nor an animal, it must be a vegetable. Vegetables are the manufacturers or producers of protein; animals are the destroyers or consumers of it.[1] You have now found that the torula or yeast-cell is a plant, and not an animal. The next question is, What kind of a plant is it? Mostly all plants need the sun, but the yeast-plant grows as well in the dark as in the light. Plants that need the light are always green; they take in carbonic acid, and give off oxygen, but the torula has no green color, and it takes in oxygen and gives off carbonic acid. Those plants which give off carbonic acid, grow in the dark, and are not green, are called fungi. The mushrooms and toadstools are fungi. Now let us see how many things you have learned about yeast: First, that it is alive; second, that it is a plant; third, that it is a fungus.

When first you try to study this lobster, you will perhaps think, as I thought, "How can I straighten out such a queer, crusty, clawy thing as that?" But, though the lobster looks as hard as the Greek alphabet, he is as easy as your own A, B, C, when once you find him out. You know the corolla or crown of the bean looked so hard, but it all came out nicely into five leaves, or petals, as soon as you knew how. Now let us see if we can find and name the different parts of the lobster. (You must have a real lobster before you to look at while I talk. The crawfish or crayfish that lives in brooks and rivers is fashioned after the lobster, only smaller; so one of these can be studied by those of you who live inland.) One thing is very certain —he has a great many different parts, very unlike each other. First, you see (Fig. 15), he is covered with a shell, which, like the mussel's and clam's, is his exo-skeleton. This shell is very hard, like stone, and it is colored purplish black with pale spots here and there. The lobsters which you see in shops are always scarlet. When these poor fellows are caught, they are plunged alive into boiling water, which turns the black coat red. This outside shell or exo-skeleton is made up of a great many different pieces, instead of two, as the mussel's; but those pieces are shaped and joined in such a way as to make three divisions of the body—a head, a thorax, or breastplate, and an abdomen. The head-piece of the shell is pointed in front, forming the beak or frontal spine (Fig. 15). Behind this head-piece is a groove or seam where the head joins the breast or thorax, making the two pieces of shell which cover the head and breast all one. So the first and second divisions of the body thus joined in one are called the cephalo-

[1] Such plants as the Venus fly-trap seem to be an exception to this demarcation between the two kingdoms. These plants really digest protein matter, being supplied with what may be termed prehensile organs for capturing their prey. Dr. Hooker suggests that these plants are not exceptional and singular; that they simply continue through life the process begun by the germ when it nourishes itself upon the ready-made food stored up in the seed.

thorax or head breastplate. The large piece of shell, with the seam that covers the back and sides of the cephalo-thorax, is called the carapace or shield (Fig. 15). It is the front sharp point of this shield (carapace) that is called the frontal spine or beak. Behind the head and breast (cephalo-thorax) lies the third division of the body—the

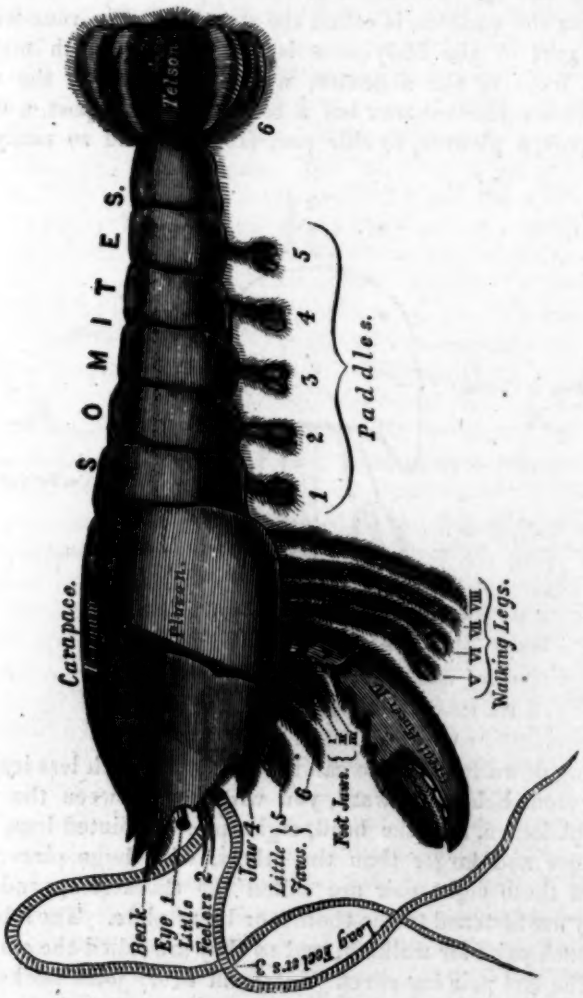

Fig. 15.

abdomen—which is made up of seven pieces or joints. The first six joints are called somites (Fig. 15) or bodies, and the last joint or tail-piece is called a telson, which means end. So the body of the lobster is made up of six somites and a telson. Each body-piece has a pair of soft-jointed paddles on its under side (Figs. 15, 16), and these are

called swimmerets or little swimmers. The lower joints of these paddles have two broad, flat toes. The paddles on the last or sixth somite are different from the others; they are wider and turned backward (Fig. 15) so as to lie at each side of the tail-piece, telson; and these great-fingered paddles, taken with the telson, form what is called the tail-fin. The under or ventral part of each somite, which lies between the paddles, is called the sternum. The rounded upper or dorsal part of the body-piece is the tergum, which means the back. In front of the abdomen, with its somites, is the cephalo-thorax. This cephalo-thorax has a tergum, or back part, a sternum, or under part, a pleuron, or side part (Fig. 15), and so many things

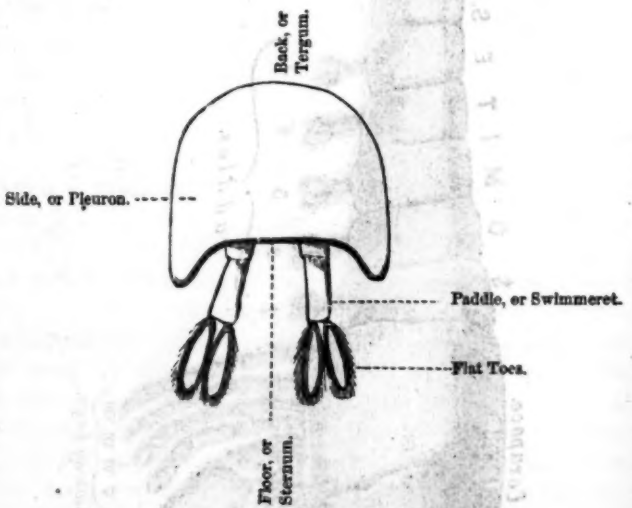

FIG. 16.—ONE OF LOBSTER'S BODY-PIECES, OR SOMITES.

are hanging down from it one can hardly count, much less learn them. Counting from behind forward, you will find between the lobster's body, or abdomen, and the head, eight pair of jointed legs, one pair much longer and larger than the others, with huge pincers at the ends. All these eight pair are called the thoracic appendages, because they are fastened to the thorax, or breastplate. The lobster uses the four back-pairs for walking, and so they are called the ambulatory limbs. The last pair has seven joints, and every joint works in a different direction; so, when these hind-legs start off, it is hard to tell where they intend to go. The next pair of walking-legs are like the hindmost pair, except that the first joint sends out a piece above it, which is kept out of sight in a little room in the side of the lobster (Fig. 22). We shall say more about this room by-and-by. The two front pair of walking-legs send up pieces also into this chamber, but the end of the leg is different from the last two pairs, for they

have pincers, or chelæ. Now we have come to the largest pair; the chelæ, or pincers at the ends, are so large and strong that they are called the "great chelæ." They are the lobster's weapons of defense. When he is taken prisoner, that is, seized by one of his claws, he quietly leaves the claw in the hands of his astonished captor, and beats his retreat as fast as possible. He has another odd way of laying down his arms when he is frightened by a great noise, such as thunder, or the firing of a cannon. It is no uncommon thing to find a number of these broken swords lying about among the rocks, showing where there has been a lobster fright or fight. As soon as one claw goes, another takes its place, but it is some time before the new one gets as long and strong as the old one. You will notice quite a difference between the two large claws, or forceps. In one, the teeth are large and blunt (Fig. 17), and in the other they are very sharp (Fig. 18).

FIG. 17.—LARGE-TOOTHED CLAW.

FIG. 18.—SMALL-TOOTHED CLAW.

The blunt-toothed pincers the lobster uses as an anchor to moor himself, while with the other he attacks and seizes his prey. So much for the great claws, or chelæ. The next three pair are called maxillipedes, or foot-jaws, because they act both as teeth and feet (Fig. 15). The hindmost foot-jaw has three divisions. One branch passes up into the side-chamber of the lobster; the middle branch is long and jointed: this, and its fellows on the other side, act as a pair of scissors, cutting the food. The third branch is jointed, and is a walking-leg. The middle foot-jaw (maxillipede) is much like the last, while the front one does not send a piece upward into the side-chamber (Fig. 22), and one of its branches is flattened out, so as to look like leaves. The four walking-legs, the great pincers (chelæ) and the three pair of foot-jaws (maxillipedes), making eight pair in all, belong to the lobster's breast (thorax). Now we come to the head, which is provided with six pair of "hangers-on," or appendages. The two back-pair belonging to the head are called maxillæ, because they lie at the side of the mouth, and are like jaws. The hindmost of the jaws—or maxillæ—on each side has a boat-shaped, or oval plate (Fig. 22), which lies at the front entrance of the side-chamber, about which we will hear more presently. The ends of the front pair of little jaws (maxillæ) are leafy, like those of the front pair of foot-jaws (maxillipedes). Now we come to the jaw itself, or mandible, which has strong teeth, bears a small appendage, the palp, and lies at the side of the mouth. From

all this you see that the mouth of the lobster is well armed with teeth and scissors to tear and cut its food. Counting from the front, it has first the true jaws (mandibles); then the two pair of little jaws (maxillæ); and these are followed by the three pair of foot-jaws (maxilli-

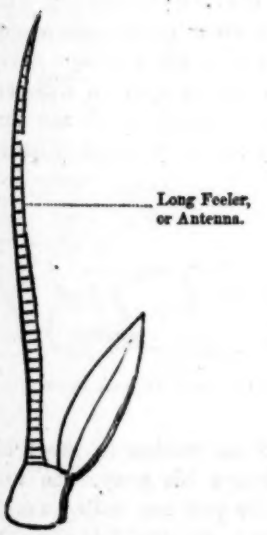

FIG. 19.

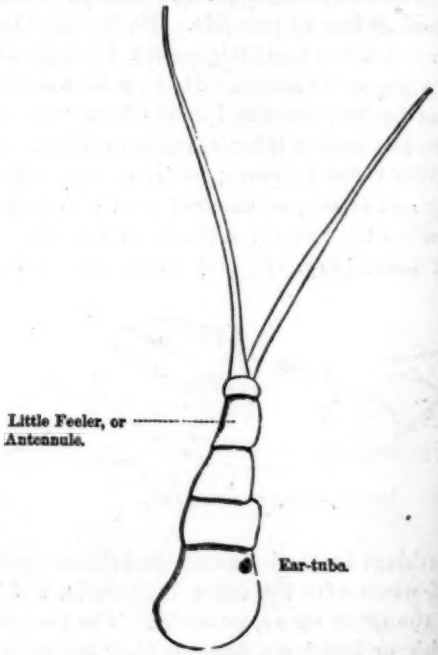

FIG. 20.

pedes) making, altogether, six pair, which are all turned up against the mouth. In front of the jaw are two very long jointed feelers called antennæ, but you seldom see them at their full length (Fig. 15); they are easily broken (Fig. 19). Next to the feelers (antennæ) are two

FIG. 21.

little feelers, or antennules (Figs. 15, 20); and last of all, in front, comes a pair of joints which support the eyes (Fig. 21), called the optic pair of appendages. Now let us begin with the eyes, and go back to the tail, to see how many pairs of feelers, jaws, hands, feet,

and paddles the lobster owns (Fig. 15). He has six pairs attached to the head, eight pair to the breast (thorax), and six pairs to the body (abdomen); in all, twenty pairs, and very few of these appendages are alike.

NAMES OF LOBSTER'S APPENDAGES.

Head appendages.....	I pair....	Eye-stalks.	
	II "	Antennules, or small feelers.	
	III "	Antennæ, or great feelers.	
	IV "	Mandibles, or true jaws.	
	V "	Maxillæ, or little jaws.....	First pair.
	VI "		Second "
Thoracic appendages..	VII "	Maxillipedes, or foot-jaws..	First "
	VIII "		Second "
	IX "		Third "
	X " ...	Chelæ, or pincers.	
	XI "	Ambulatory limbs, or walking-legs.....	XI. and XII., with pincers.
	XII "		XIII. and XIV., without pincers.
	XIII "		
	XIV "		
Abdominal appendages.	XV "	Swimmerets, or little swimmers.	
	XVI "		
	XVII "		
	XVIII "		
	XIX "		
	XX "		

You now have a pretty good idea of the exo-skeleton, or hard outside part of the lobster, and we shall look next at the soft parts inside (Fig. 22). The mouth seems a very good place to begin at, and you will find it between the mandibles, or jaws. In front of it is a lip, shaped like an escutcheon, and is called the *labrum*, which means lip. At the back of the mouth is another lip, the *metastoma*, meaning beyond the mouth, and this is looked upon as the lower lip. The mouth, as in the mussel, opens into a gullet, or œsophagus. This meat-pipe opens into a four-cornered box (Fig. 22)—the stomach—which is very curiously made.

Near the centre of the box the walls come almost together, dividing it into two parts: the front part is the larger, and it is called the cardiac end, because in the human body the first part of the stomach points toward the heart, but you see, in the lobster, it points away from the heart. It contains three strong, colored teeth, fastened to a T-shaped frame (Fig. 23), and worked by muscles which are fastened to the inside of the breastplate (carapace). These teeth meet in the middle of the stomach, and form a powerful grinding-machine, which crushes the food like the stones in a mill (Fig. 24). Sometimes, when you find the empty shell of a lobster on the sea-shore, you can see a perfect mould of the old mill—"the mill-wheel gone to decay." How the lobster gets out of his shell, and how he turns the mill out of his stomach, we shall study after a while. The small back part of the

stomach is called the pyloric end, and it is made inside like a sieve or strainer. The sides are stuffed out in the centre like cushions, and quite covered with hairs (Fig. 25). Let us see why. Pylorus means gate-keeper. It protects or guards the intestine from all intruders,

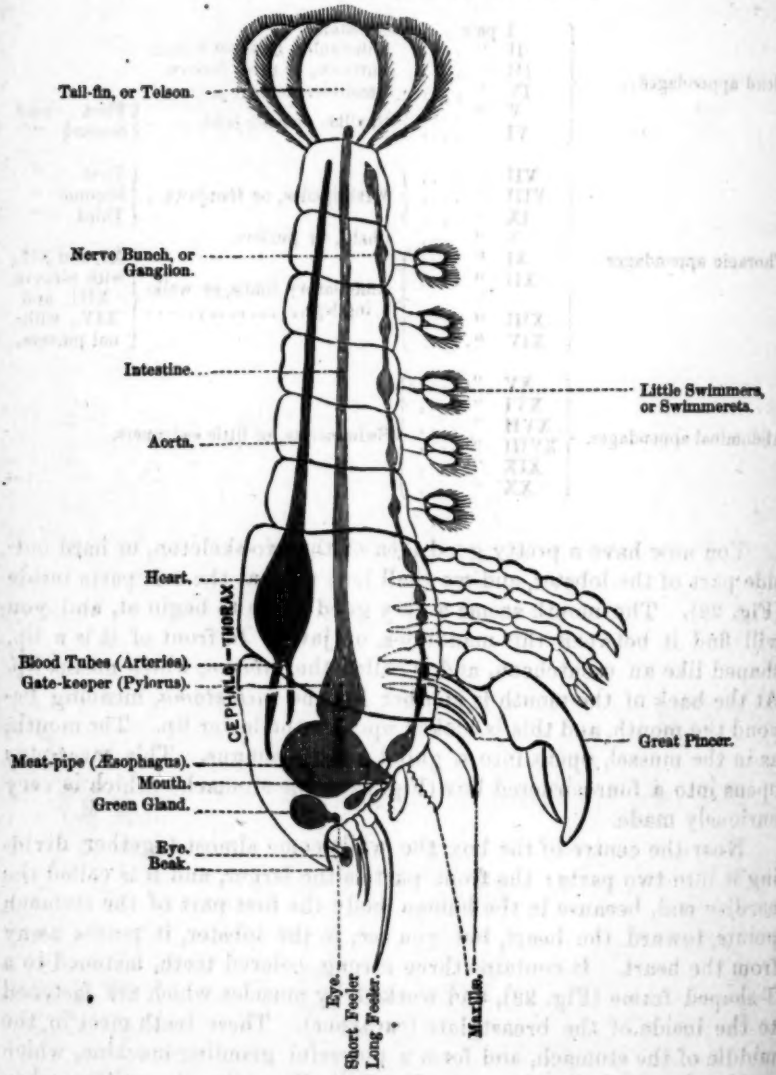

FIG. 22.

such as big pieces of meat and hard bodies. None but the finest particles can pass through the strainer, and hence this pylorus is a very good gate-keeper. The intestine does not go wandering about in the body like the mussel's, but passes straight back (Fig. 22), and ends at the

anus, at the under part of the tail-piece (telson). On each side of the cephalo-thorax lies a long, soft, yellowish-green mass. This is the liver, and it opens into the small, pyloric end of the stomach by several ducts or pipes on each side. Away up in the front part of the cephalo-thorax, at the base of the feelers (antennæ) on either side

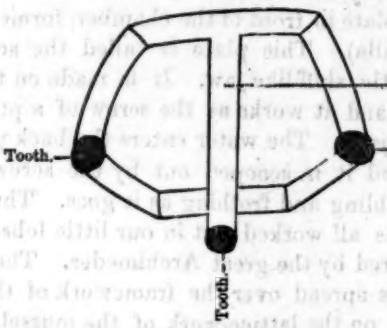

FIG. 23.—THE LOBSTER'S MILL.

you may see a soft green mass called the "green gland" (Fig. 22). This is supposed to be the kidney. Next we will take a look into the side-chambers (Fig. 22) of the cephalo-thorax, and see what the three pair of walking-legs, the great pincers (chelæ), and the two pairs of jaw-feet, are doing in there. In each chamber we find eighteen little,

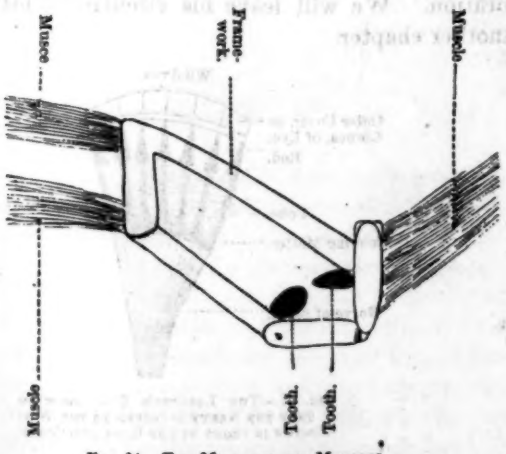

FIG. 24.—THE MILL AND ITS MUSCLES.

FIG. 25.—THE HAIRY CUSHIONS AT THE SMALL END OF THE STOMACH, THROUGH WHICH THE FOOD IS STRAINED.

tapering, feathery-like bodies. Each has a central stem, surrounded by fine, feathery filaments. They look very much like so many little bottle-brushes (Fig. 22). These are the gill-plumes, and this room is called the gill, or branchial chamber. The gills are placed in two sets, six in one and twelve in the other. The first row is fastened to

the six feet or appendages of the breast (thorax) which we found pushing themselves up into the chamber (Fig. 22). The other twelve are fastened to the pleuron or side-pieces of the cephalo-thorax. These gills are not covered with stiff hairs (cilia) as the mussel's, so there must be some other plan of moving the water. There is a very curious piece of machinery at the front entrance. You remember the oval or boat-shaped plate in front of the chamber, formed by the hindmost little jaw (maxilla). This plate is called the scapho-gnathite, which means the little skiff-like jaw. It is made on the plan of the Archimedean screw, and it works as the screw of a propeller, and is set in motion by the jaws. The water enters the back part of the gill-chamber by a slit, and it is scooped out by the screw through the opening in front, bubbling and frothing as it goes. Thus the mechanism of the screw was all worked out in our little lobster long years before it was discovered by the great Archimedes. The tiny net-work of the blood-vessels is spread over the framework of the gill-plumes, just as you found it on the lattice-work of the mussel's gill-pockets. As the screw propels the water through the branchial or gill chamber the blood takes out the oxygen from the air in the water, and gives back carbonic acid. You remember how the strong hairs (cilia) of the pockets sweep the water along over the mussel's gills, and how the little blood-vessels take up their oxygen and give up their carbonic acid. The gills that are fastened to the legs move when the legs move, and the faster they go the more water they use. So much for the lobster's breathing or respiration. We will leave his circulation, his muscles and nerves, for another chapter.

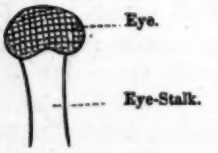

FIG. 26.

FIG. 27.—THE LOBSTER'S EYE, SHOWING HOW THE NERVE IS JOINED TO THE WINDOWS IN FRONT BY THE RODS AND CONES.

The eyes, as you have seen, are away in front (Figs. 15, 22) at the ends of the first pair of appendages—the eye-stalks. The eye is kidney-shaped; instead of having one window or pupil as your eye has, through which the light enters, the whole front is divided into squares like old-fashioned window-panes (Fig. 26). Each square is really a separate eye, and this is what is called a compound eye. The lob-

ster's eyesight must be very good, for, besides having all those eyes, the stalks are jointed so that he can turn them in different directions. The nerve which goes to the eye is called the optic nerve, and it is connected with each square by pretty rods and cones, which look like those in your own eye (Fig. 27). The rods and cones are covered with coloring-matter or pigment, which turns red when it is boiled. The optic nerve is a nerve of sensation, because it gives the lobster the sense of sight.

Now, where are the lobster's ears? Not in the foot, as the mussel's, but in their proper place—the head. If you look at the base of the little feelers, on each side you will find a little three-cornered slit, covered with hairs (Fig. 28). This slit leads into a small sac filled

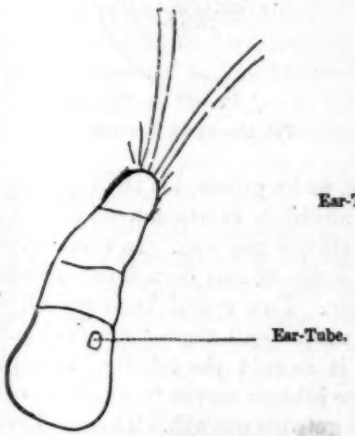

Fig. 28.—Little Feeler, or Antennule, showing Ear-Tube at its Base.

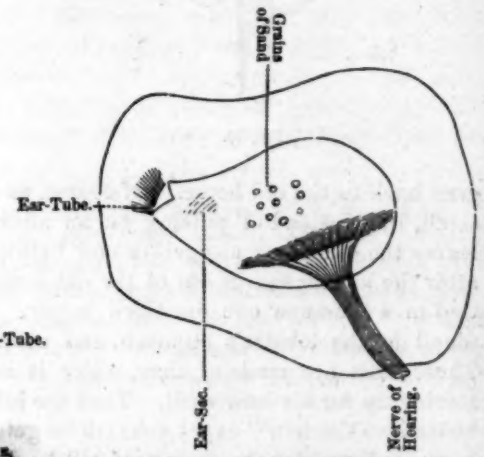

Fig. 29.—The Lobster's Ear.

with water. One side of this sac is pushed inward to form a sort of fold or pocket, in which a nerve which comes from the brain or head—ganglia—spreads itself out (Fig. 29). The side of the pocket toward the water is covered with fine hairs, and these hairs touch against little bits of sand which get into the water through the outside slit (Fig. 30). These particles of sand are like the tiny stones or otoliths you found in the mussel's ear-sac, and they, likewise, help to increase the sound. The lobster's ear is made on much the same plan as your own; the sac is really a fold of the lobster's skin, which is pushed in as you might push in the crown of your soft hat. Now, I dare say you are wishing to hear about the lobster's bairns or little ones. The lobster's eggs are covered by a soft, sticky glue, which fastens them to the long hairs which cover the paddles under the abdomen (Fig. 22). The good mother-lobster doubles up her body so that the eggs are all folded inward safe from harm. Hundreds of eggs are carried in this way, and when the lobster is boiled they turn red and form what is

called the coral. The baby-lobsters differ greatly from their parents. Their eyes are very large, and set in the head instead of on eye-stalks. They have a great rounded head-shield (carapace) and a small body (Fig. 31). The limbs are not at all like the lobster's; altogether, he looks as if his eyes and head were running away with him. As soon as he is hatched he begins to swim about and feed himself, and never

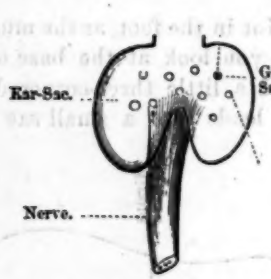

FIG. 30.

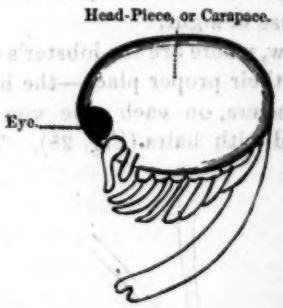

FIG. 31.—YOUNG LOBSTER.

goes back to the old home. Of course, as he grows, his shell gets too small, but, instead of putting on an addition as the mussel does, he leaves the old house altogether and builds a new one. In three days after the lobster moves out of the old house he has been found all settled in a bran-new one one-third larger. Two round balls are often found in the lobster's stomach, and people call them "crab's-eyes." These balls are made of lime, which it is said the lobster has been storing up for his new shell. Thus the lobster moves "out of the old house into the new" every year till he gets his growth. Then he lives contentedly under the same roof till he dies, or till some one throws him into a lobster-pot.

THE ELECTRICAL GIRL.

TRANSLATED FROM THE FRENCH OF LOUIS FIGUIER, BY CLARA HAMMOND.

IN the beginning of 1846, a year memorable in the history of table-turning and spirit-rapping, Angélique Cottin was a girl of fourteen, living in the village of Bouvigny, near La Perrière, department of Orne, France. She was of low stature, but of robust frame, and apathetic to an extraordinary degree both in body and mind. On January 15th of the year named, while the girl was with three others engaged in weaving silk-thread gloves, the oaken table at which they worked began to move and change position. The work-women were alarmed; work was for a moment suspended, but was soon resumed. But, when Angélique again took her place, the table began anew to

move with great violence; she felt herself attracted to it, but, so soon as she touched it, it retreated before her, or was even upset. The following morning similar phenomena were observed; and before long public opinion was very decided in affirming that Angélique Cottin was possessed of a devil, and that she should be brought before the parish priest. But the *curé* was a man of too much common-sense to heed their request for an exorcism, and resolved to see the facts for himself. The girl was brought to the *curé's* house, and there the phenomena were repeated, though not with the same intensity as before: the table retreated, but was not overturned, while the chair on which Angélique was seated moved in a contrary direction, rocking the while, and giving Angélique great difficulty in keeping her seat. These effects were so remarkable as to attract a great deal of attention; and so many came to see the demonstrations that the girl's relations, who were in straitened circumstances, thought to make a lucrative business of her singular faculty by exhibitions from time to time. Various professional men testified to her performances, of which the following letter from Dr. Beaumont-Chardon, of Mortagne, gives the usual account:

"This is what I saw," says this physician.

"1. Repulsion and attraction, bounding and displacement of a massive table; also of another table, mounted on casters, about three metres by two; another square table, in oak, about a metre and a half in size; an arm-chair, of mahogany, very massive. All these movements took place from the voluntary or involuntary contact of Angélique's clothes.

"2. When she was seated, overturning and repulsion of the young girl and the person who was occupying the same chair; a momentary adherence of the chair to the girl's dress was seen several times. Cessation of these effects when the chair and the young girl were placed upon glass or oil-cloth, or when the girl was placed upon the chair without having the feet of the latter touch the floor, effects generally less upon waxed floors or carpets.

"3. Great disturbance noticed in the girl, recalling that which is produced by an electric discharge, when a piece of wood, a stick, a shovel, or tongs, was brought in contact with the vertebral column. My finger held toward her forehead, or the top, and above all, the back of her head, either by actual contact, or at a distance of two centimetres, produced the same effect as it had done when brought in contact with the elbow of the left arm—disappearance of this effect when a piece of oil-cloth was interposed between the arm and the object.

"4. Painful and insupportable sensation of itching when one or two iron rods, strongly magnetized, were held several centimetres from the extended fingers of her left hand, or from her head; non-magnetized iron did not produce this effect. A magnetized needle, suspended horizontally from the ceiling by a long thread, deviated from the direction of the terrestrial magnetic axis, and oscillated at the approach of the girl's left arm.

"The young girl was generally heavily charged when I was near her, because I did not arouse in her any feeling of mistrust, but always endeavored to spare her suffering; I thought that, in order to appear to the best advantage, her mind must be free, and she herself gay and lively, although her will seemed to be entirely void of influence."

Angélique's relatives resolved, at length, to take the *electrical girl* to Paris in order to submit her to the examination of the academicians. During the public *séance* on the 17th of February at the Académie des Sciences, the secretary, Arago, published the experiments to which Dr. Sanchon had subjected the girl, and read a notice given him by this physician, which appeared in the official *Compte Rendu* of this session. It is as follows:

"I have twice," says Dr. Sanchon, "seen the electrical girl (Angélique Cottin). A chair which I was holding as firmly as possible with my foot and both hands, was suddenly torn from my grasp when she sat upon it. A little strip of paper which I balanced on my finger was blown away several times as though by a sudden rush of wind. A dining-table of considerable size, and quite heavy, was several times displaced and pushed by the mere contact of the girl's clothes. A small paper wheel, placed vertically or horizontally upon its axis, received a rapid motion from the emanations which proceeded from the child's wrist and elbow-joint. A very large and heavy sofa, on which I was seated, was violently pushed against the wall when the young girl placed herself beside me. A chair held to the ground by strong persons, on which I sat in a manner so as to occupy but half of it, was suddenly pushed from under me when the girl sat upon the remaining half. A remarkable fact is, that each time the chair was raised, it seemed to adhere to the girl's clothes; she followed it for an instant, and then disengaged herself. Two little balls of elder-wood, or small pieces of quill suspended by a silk thread, were disturbed, attracted, and finally separated one from the other.

"The young girl's emanations were not permanent during the day; they appeared in the evening, from seven to nine o'clock: this gives me the idea that her last meal, which she takes at six o'clock, has some influence in regard to them. They recurred on the anterior surface of the body, particularly at the wrist and elbow. They only recurred in the left side; the arm on this side was warmer than the other; a gentle warmth was radiated from it as from a member on which a vivid reaction takes place. This part of the body was trembling and continually affected by unusual contractions and quivering, which seemed to be communicated to any hand that touched her. During the time that I noticed this young person, her pulse varied from 105 to 120; it often appeared irregular. When the girl was removed from the common reservoir, either by placing her in a chair without letting her feet touch the ground, or by resting her feet against those of another person standing before her, the phenomenon did not take place; it also ceased when she put her hands beneath her on sitting down. A waxed floor, a piece of oil-cloth, or a plate of glass, put under her feet or upon her chair, equally destroys her electric faculty.

"During the paroxysm, the girl can hardly touch any thing with her left hand without causing it to be thrown some distance; when her clothes come in contact with pieces of furniture, she attracts, displaces, and finally overturns them. This will be better conceived when the fact is known that, at each electric discharge, she endeavors to escape in order to avoid the result; she says that she always feels a pricking sensation at her wrist and elbow. In searching for the pulse in the temporal artery, not being able to appreciate it in the left arm, my fingers inadvertently touched the nape of the neck; instantly the girl uttered a cry, and disengaged herself from me. In the region of the cerebellum (I have tested this many times), where the muscles of the upper portion of the

neck are inserted into the cranium, there was such a sensitive spot that the girl could not bear to have it touched—a spot which retained all the sensations she felt in her left arm.

"The child's electric emanations seemed to occur at intervals, and successively, in different portions of the anterior part of her body. I remarked on this occasion that in the displacement of the table, which requires great force, the electricity was in the base of the brain.

"Whatever these emanations are, they are produced by a gaseous current producing a sensation of cold. I distinctly felt a momentary breath upon my hands, similar to that made by the lips.

"This irregularity in the emission of the fluid seems to result from numerous causes. First, the continual preoccupation of the girl, who always glances behind her when any one or any thing touches her; and, finally, the apprehension which she has of the phenomenon; for, as soon as it becomes manifest, she rapidly endeavors to escape, as though repulsed by some contrary force. It is only when she thinks of nothing, or when her thoughts are otherwise engaged, that the phenomenon is most sudden and intense.

"Each phenomenon is marked by extreme fright in the girl, flight, and a general air of alarm. When she touches the north pole of a magnet with the end of her finger, she receives a violent shock. The south pole produces no effect. The magnet was charged in such a manner that the north pole could not be distinguished from the south; but the young girl knew the difference.

"She is very strong and in excellent health. Her intellectual capacities are but little developed; she is a village girl in every sense of the word.

"PARIS, *February* 15, 1846."

After having read the preceding notice, Arago related all that he had himself observed concerning Angélique Cottin, whom her relations had taken to the Observatory. In the presence of MM. Mathieu, Laugier, and Gougin, he confirmed the following phenomena: When Angélique Cottin touched a sheet of paper lying on a table it was instantly attracted toward her hand. Angélique approached a table, which was repelled as soon as it came in contact with her apron. She seated herself upon a chair with her feet resting on the floor, and the chair was thrown violently against the wall, while the young girl was sent in another direction. This experiment succeeded whenever it was tried. Neither Arago, Gougin, nor Laugier, could hold the chair immovable, and M. Gougin, seating himself in one-half of it, while the girl occupied the other, was thrown upon the floor as soon as she took possession of it.

Arago then asked that a committee should be appointed to examine these phenomena. The Academy selected Arago, Becquerel, Isidore Geoffroy Saint-Hilaire, Babinet, Rayer, and Pariset.

This committee assembled, on the following day, in the Jardin des Plantes, but the experiments were unfavorable in regard to the reality of the electric properties of Angélique Cottin.

Here is the committee's report:

"In the session of the 16th of February the Academy received from M. Cholet and Dr. Sanchon two notices relative to the extraordinary faculty which, it is

said, was developed about a month ago in a young girl from Orne, Angélique Cottin, aged fourteen years. The Academy, in conformity with its usual custom, appointed a committee to examine these alleged facts, and to give an account of the result. We will discharge this duty in very few words:

"It was affirmed that Mdlle. Cottin exercised a most intense action of repulsion upon bodies of all kinds whenever a portion of her garments touched them. Accounts were even given of heavy tables being overturned by the simple contact of a silk thread. No effect of this kind was manifested before the committee.

"In the narratives communicated to the Academy it was affirmed that a magnetized needle, under the influence of the girl's arm, performed rapid oscillations, and finally fixed itself quite far from the magnetic meridian. When tried before the committee, a needle, delicately suspended in the same way and under the same circumstances, experienced neither permanent nor momentary displacement.

"M. Sanchon thought that Mdlle. Cottin possessed the faculty of distinguishing the north pole of a magnet from the south pole, by merely touching them with her fingers. The committee was convinced, by varied and numerous experiments, that the young girl does not possess the capacity attributed to her of determining the poles.

"The committee need not enumerate these useless attempts. It will simply content itself with declaring that *the only one of the alleged facts which was realized before them was that concerning the sudden and violent movements of chairs in which the young girl seated herself.* Upon serious suspicions arising as to the manner in which these movements occurred, the committee has decided that they shall be submitted to an attentive examination. It frankly announces that the investigations tended to discover the fact that certain *habitual manœuvres hidden in the feet and hands* could have produced the observed fact. *M. Cholet now declared that the young girl had lost her powers of attraction and repulsion*, and that we should be notified as soon as they were restored. Many days have passed since, yet the committee has received no intelligence. We have learned, however, that Mdlle. Cottin is daily received in drawing-rooms *where she repeats her experiments.*

"After having fully weighed the circumstances, the committee is of the opinion that the communications transmitted to the Academy on the subject of Mdlle. Angélique Cottin should be considered *as never having been sent in.*

(Signed) "Arago, Becquerel, Isidore Geoffroy Saint-Hilaire, Babinet, Rayer, Pariset."

DARWIN AND HAECKEL.[1]

By Prof. T. H. HUXLEY, F.R.S.

OCTOBER 1, 1859, the date of the publication of the "Origin of Species," will hereafter be reckoned as the commencement of a new era in the history of biology. It marks the hegira of Science from the idolatries of special creation to the purer faith of evolution. That

[1] "Anthropogenie. Entwickelungsgeschichte des Menschen" (History of the Evolution of Man). By Prof. Ernst Haeckel. Translation in press by D. Appleton & Co.

great conception, which had dawned upon the minds of the patriarchs of philosophy—which had been embalmed in the immortal poem of Lucretius—which had been submerged, but not drowned, in the muddy deluge of Hebrew mythology and schoolmen's philosophy (miscalled Christianity) in the middle ages—and had struggled to the surface, much besmirched, by Lamarck's help—at length stood upon a firm dry quay, built by Darwin's hand, and made water-tight by a goodly contribution of Wallace's cement.

For the first time in history, sound scientific reasonings—the force of which has increased with every year of the fifteen which have elapsed—introduced such conclusions as the following:

"I believe that animals have descended from at most only four or five progenitors" ("Origin of Species," first edition, p. 484).

"I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form" (Ibid., p. 484).

"In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown upon the origin of man and his history" (Ibid., p. 488).

". . . I view all beings, not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Silurian system was deposited. . . ." (Ibid., pp. 488, 489).

"As all the living forms of life are the lineal descendants of those which lived long before the Silurian epoch. . . ." (Ibid., p. 489).

"There is a grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one" (Ibid., p. 490).

There is no uncertain utterance here. There has been no special creation. All beings which now live are descended from primordial forms which existed before the oldest fossiliferous rocks were deposited. Man is no exception, but he and his highest faculties are as much products of evolution as the humblest plant, or the lowest worm.

A more clear and bold statement of the scope and tendencies of the doctrine advocated by Mr. Darwin could not have been put into words; and those who recollect the somewhat fiery controversies which were carried on, during the years which immediately followed 1859, need not be reminded that the *cheval de bataille* of the opponents of Darwinism was, to hold up to scorn and ridicule the application of his views to man, so distinctly indicated by the author of the theory when it was promulgated.

It seems almost absurd to produce evidence of what is so notorious. Yet it happens to be worth while to quote an article which appeared in the *Quarterly Review* for July, 1860. It is a production which should be bound up in good stout calf, or better, asses' skin, if such material is to be had, by the curious book-collector, together with

Brougham's attack on the undulatory theory of light when it was first propounded by Young, and it is chiefly remarkable for the magisterial airs assumed by a critic so fearfully and wonderfully ignorant of the subject with which he deals that he believes the blood-corpuscles to be produced by evaporation of the blood![1] The following extracts will, however, leave no doubt that, even to so unprepared an apprehension, Mr. Darwin's language was plain enough:

"This is the theory which really pervades the whole volume. Man, beast, creeping thing, and plant of the earth, are all the lineal and direct descendants of some individual *ens*, whose various progeny have been simply modified by the action of natural and ascertainable conditions into the multiform aspect of life which we see around us" (p. 231).

"If, with Mr. Darwin, to escape the difficulty of supposing the first man at his creation to possess in that framework of his body 'false marks of nourishment from his mother's womb,' with Mr. Darwin you consider him to have been an improved ape" (p. 253).

"First, then, he (Mr. Darwin) not obscurely declares that he applies his scheme of the action of the principle of natural selection to MAN himself, as well as to the animals around him" (p. 257).

Exactly fourteen years after this distinct testimony to the plainness of Mr. Darwin's speech on these matters, last July, namely, the very same *Review* had an article entitled "Primitive Man." Possessed by a blind animosity against all things Darwinian, the writer of this paper outrages decency by insinuations against Mr. George Darwin, well calculated to damage a little-known man with the public, though they sound droll enough to those who are acquainted with my able and excellent friend's somewhat ascetic habits; and, by way of preparation for the attack upon the son, the anonymous reviewer charges the father with deliberate duplicity:

"It is one of the calamities of our time and country that unbelievers, instead of, as in France, honestly avowing their sentiments, disguise them by studious reticence—as Mr. Darwin disguised, at first, his views as to the bestiality of man" (*loc. cit.*, p. 63).

Messieurs the Reviewers, you diametrically contradict one another, and one of you must bear the responsibility of a direct and deliberate untruth: which is it? The one who, writing in July, 1860, said there was no obscurity about Mr. Darwin's views on this matter? Or the one who, writing in July, 1874, accuses him of having at first disguised his views? Settle it between yourselves. If it were necessary for me to give an opinion on so delicate a matter, assuredly I could have no ground for hesitation. For, on becoming acquainted with Mr. Darwin's views in 1858, I set myself to inquire, much more seriously than I had done before, whether the hiatus between man and apes, indicated

[1] The passage is worth embalming: "Or what advantage of life could alter the shape of the corpuscles into which the blood can be evaporated?" (*loc. cit.*, p. 247).

by the Cuvierian classification, and insisted upon by his followers, to the great satisfaction of the opponents of the doctrine of evolution, really had an existence in Nature. I came to the conclusion that it had none; I stated the grounds of these conclusions to those who attended my lectures in 1859–'60; a battle, which was somewhat notorious in its day, took place at the meeting of the British Association at Oxford in 1860, and turned upon Mr. Darwin's views of the evolution of man; while, in 1863, I summed up the then state of the question in a little book, entitled "Man's Place in Nature," which did its work in several languages beside my own, and is now out of print and gone to the limbo of forgotten things: which is its proper place, now that Mr. Darwin has had leisure to state his own views more fully, though not more distinctly, than in the "Origin of Species," in the "Descent of Man."

Mr. Darwin reticent about his views respecting the origin of man! Why, for years after the publication of the "Origin of Species," one could not go to a dinner-party without hearing them; and, whether you took up the last number of *Punch*, or the last sermon, the chances were ten to one that there was some allusion to the "missing link."

Under these circumstances, the high moral tone assumed by the *Quarterly* reviewer—him of 1874, I mean—is truly edifying. Joseph Surface could not have done better. Unless I err, he is good enough to include me among the members of that school whose speculations are to bring back among us the gross profligacy of imperial Rome. This may be doubtful. But what is not doubtful is the fact that misrepresentation and falsification are the favorite weapons of Jesuitical Rome; that anonymous slander is practice, and not mere speculation; and that it is a practice, the natural culmination of which is not the profligacy of a Nero, or of a Commodus, but the secret poisonings of the papal Borgias.

I remember that when, in 1862, I showed the proofs of "Man's Place in Nature" to a cautious and sagacious friend of mine—an expert in such matters—he had nothing to say against my arguments, but much to urge against the prudence of publishing them. Doubtless he foresaw that an unscrupulous critic, sheltered by his anonymity, might charge me with advocating the "bestiality of man," and with, thereby, endeavoring to loosen those moral bonds which hold society together. It seemed to me, however, that a man of science has no *raison d'être* at all, unless he is willing to face much greater risks than these for the sake of that which he believes to be true; and, further, that to a man of science such risks do not count for much—that they are by no means so serious as they are to a man of letters, for example. Happily, the reputation and real success of a votary of the physical sciences are now wholly independent of the periodicals which are pleased to call themselves "influential organs of public opinion." The only opinion he need care about, if he care for any—

and he is all the wiser and happier if he care for none—is that of about a dozen men: two or three in these islands, as many in America, and half a dozen on the Continent. If these think well of his work, his reputation is secure from all the attacks of all the able editors of all the "influential organs" put together. So that I do not suppose that Mr. Darwin troubles himself much about this charge of dishonest reticence, which would be so ludicrous if it were not so shameful to its author; and I have thought it worth while to expose its foolish falsity merely in the interests of the honor of English journalism, in the hope of putting a stop to such malpractices, by calling the attention of the public to the most conspicuous lapse from that honor which has happened within my recollection.

The book, the title of which heads this article, Haeckel's "Anthropogenie," is remarkable in many ways: not least as a milestone, indicating the progress of the application of the theory of Evolution to Man, since Darwin set us all to thinking afresh upon that subject.

The position I took up, in 1863, was a very guarded one, as the state of knowledge at that time demanded. All I had to say came to this: If there is reason to believe that the lower animals have come to be what they are by a process of gradual modification, then there is nothing in the structure of man to warrant us in denying that he may have come into existence by the gradual modification of a mammal of ape-like organization. And, of the many criticisms with which my little book has been favored here and abroad, I have met with none which, in the slightest degree, shakes that position.

Prof. Haeckel stoops at much higher game. His theme is "Anthropogeny"—the tracing of the actual pedigree of man—from its protoplasmic root, sodden in the mud of seas which existed before the oldest of the fossiliferous rocks were deposited, in those inconceivably ancient days, which, for this earth, at any rate, were the real *juventus mundi*, to its climax and perfection—say in an anonymous critic of strict orthodoxy and high moral tone.

It need hardly be said that, in dealing with such a problem as this, science rapidly passes beyond the bounds of positive verifiable fact, and enters those of more or less justifiable speculation. But there are very few scientific problems, even of those which have been, and are being, most successfully solved, which have been, or can be, approached in any other way.

Our views respecting the nature of the planets, of the sun and stars, are speculations which are not, and cannot be, directly verified; that great instrument of research, the atomic hypothesis, is a speculation which cannot be directly verified; the statement that an extinct animal, of which we know only the skeleton, and never can know any more, had a heart and lungs, and gave birth to young which were developed in such and such a fashion, may be one which admits of no reasonable doubt, but it is an unverifiable hypothesis. I may be

as sure as I can be of any thing, that I had a thought yesterday morning, which I took care neither to utter, nor to write down, but my conviction is an utterly unverifiable hypothesis. So that unverified, and even unverifiable, hypotheses may be great aids to the progress of knowledge—may have a right to be believed with a high degree of assurance. And, therefore, even if it be admitted that the evolution hypothesis is, in great measure, beyond the reach of verification, it by no means follows that it is not true, still less that it is not of the utmost value and importance.

There is evidence which is perfectly satisfactory to competent judges, that we have already learned the actual historical process by which one existing species—the horse—came into existence during the Tertiary epoch. The evidence, based on the analogy of known developmental facts, that a three-toed *Hipparion* form, which lived in the Miocene epoch, gave rise, by suppression of the phalanges of its rudimental toes and some other slight modifications, to the apparently one-toed later Tertiary horse, is as satisfactory to my mind as the evidence, based on the analogy of known structural facts, which leads me to have no doubt that the said extinct *Hipparion* had a simple stomach and a certain kind of heart. If those so-called "Baconian principles," which everybody talks about and nobody dreams of putting into practice, forbid us to draw the one conclusion, they forbid us to draw the other.

The alternative hypotheses are two: either the Deity manifested his power on this earth, in the course of the Miocene epoch, by making the two primitive ancestors of all the horses out of inorganic matter, or something more unlike a horse than a *Hipparion* changed into one. The latter hypothesis is gratuitous and absurd. The former is not in itself absurd; but, unless the early chapters of Genesis mean something contrary to what they appear to mean (and one never knows what exegetic ingenuity may make of the "original Hebrew"), it is shockingly heretical, and I hasten to disown it, lest, by some such secret connection as bound Goodwin Sands with Tenterden steeple, it should land me in the cruelties of Caligula, and lead me to violate the precepts of the sagest of physicians, by indulging in Heliogabalian gluttony.

But, if the horse really has arisen in this way, what imaginable ground can there be for the enormous and, in that case, highly "un-Baconian" assumption that the deer, and the ox, and the pig, have arisen in any other way? And if there is—not perhaps the complete evidence that we happen to possess in the case of the horse—but still much better evidence than there is for the authenticity and genuineness of the books called by the name of Moses, that these animals have been produced by a similar method, why may not the hypothesis that they have so arisen take its rank among the probable conclusions of science? Even though it must, in candor, be admitted

that, as we cannot live back into the Tertiary epoch and see what went on at that time, the hypothesis must always remain, in the strictest sense of the word, unverifiable.

The fact is, that if the objections which are raised to the general doctrine of evolution were not theological objections, their utter childishness would be manifest even to the most childlike of believers. But, if the evolution of all living forms, by gradual modification, is an historical fact, why should the attempt to reconstruct the details of that momentous history be regarded as less philosophical or less laudable than the attempt of a Niebuhr, or of a Mommsen, to build up, from ruined monuments, fragmentary inscriptions, and obscure and often contradictory texts, a connected and intelligible history of Rome? Active error may advance knowledge in its efforts to establish itself; and nothing is more remarkable than the number of great things, from the discovery of America to that of the antiquity of man, which have been brought about by the attempt to establish erroneous views. But sitting still, and being afraid to stir, for fear of making mistakes, is certain to end in ruin in science as in practical life.

Prof. Haeckel is not chargeable with the fault of sitting still, and it may be that he moves too quickly now and then. In his book there are some views which I, for one, do not agree with, but as to which it is just as likely I may be wrong as he. I wish he could be persuaded to take a more liberal view of the duration of life on the earth, though he is far less miserly on that point now than when the "Schöpfungsgeschichte," formerly noticed in the *Academy*, was published. I might desire that he would not mix up phylogenetic "Stammbäume" with objective taxonomy; and I might wish that he would be a little milder with his honest opponents, though I heartily applaud his practice of dealing with critics of the other sort as mere *ferœ naturæ*.

But, when all is said and done in the way of objection, the "Anthropogenie" is a real live book, full of power and genius, and based upon a foundation of practical original work, to which few living men can offer a parallel. If anybody can read it without profiting by the abundant information and fertile suggestions of new lines of thought which it contains, all I can say is, that I envy him; and if anybody can read it without being struck by its clearness and methodical comprehensiveness, and without being convinced that the general line of argument is sound, whatever may be thought of the details, all I can further say is, I do not envy him. I trust that, like the "Schöpfungsgeschichte," the "Anthropogenie" may speedily find an English translator.—*Academy*.

"SPIRITUAL PIRATES."

By S. H. HAYWOOD.

PIO NONO has recently given to the world his infallible opinion concerning Tyndall and other modern scientists. To his apprehension they are "spiritual pirates, seeking to destroy the souls of men," and he undoubtedly has great faith in that high legal authority which says, "Pirates all nations are to prosecute."

From the Catholic stand-point the figure has a special significance. These fearless scholars have embarked upon the high-seas of scientific thought and research. Truth is the prize for which they seek. For its sake they are willing to float a flag which is always regarded as hostile by those who choose to remain forever anchored in the harbors of tradition and superstition. Along their track many a bright beacon has already been set, which marks the spot where some precious fragment has been redeemed and where some error has found its grave. But never has a ray of their light reached us without a struggle with the powers of darkness. Over all these highways of national and international thought the pope would gladly hold supreme jurisdiction. Free thought and free inquiry in almost any direction are fatal to some vital principle of Roman Catholicism. To match metaphors with his Holiness, they are spiritual sappers and miners, whose strokes tell fearfully among the foundation-stones of the Vatican.

We must concede consistency, at least, to this position of the Catholic Church. The genius of its religion is authority, and are not its subjects likely to lie stiller in the dark than when it is light about them? It is interesting and significant to notice how little its attitude toward theological or scientific inquiry has changed within the last three hundred years. Spencer in his philosophy of evolution, Darwin in his theory of natural selection, Tyndall in recasting the definitions of matter, are denounced in the spirit, and almost in the diction, of the sixteenth century. And how did it fare with Louis Agassiz, teacher, when he first ventured to assert the diverse origin of the human race? Some of us can remember. The overt acts of persecution which followed and tortured Galileo, Vesalius, and Giordano Bruno, are at present prudentially suppressed; but the spirit of the inquisitor still pursues the scientist into his laboratory or observatory, and insists that he bring thence nothing that does not harmonize with the creeds of to-day.

If the pope, Cardinal Cullen, the Dean of Manchester, and others under Catholic or High-Church influence and control, had gathered unto themselves all existing misapprehension, misrepresentation, and invective, in this direction, it were scarcely worth while to comment on a position so natural and a course so consistent with long-estab-

lished precedent. But, unfortunately, it is not so. The alarm is sounded along our own shores, and the Presbytery of Belfast finds an echo in many of our so-called evangelical churches, and even in some of those which are miscalled liberal. Our preachers seem to delight in aiming a sarcasm or shaft of ridicule at the "advanced thinkers," not forgetting to add all possible irony to tone and inflection. One sacrifices his usual taste and discrimination, and selects the epithet Pickaninny to contain his sneer. "Pickaninny Tyndall!" Does it mean any thing? If so, what? Another makes a somewhat singular classification of "infidels," putting Voltaire, Hume, Tom Paine, and Tyndall, into the same category, and consigning them all to a common and speedy oblivion. Another, more in sorrow than in anger, speaks of the "ponderous sentences of unbelief" in the Belfast Address, but quotes none of them. In a newspaper article, written at Christmas-tide to inculcate "charity, in its largest, broadest, most comprehensive sense," we read that "Science throttles Religion in high places—or tries to." By these scared theologians, scientific men are declared to be trying to annihilate the Bible, to dethrone the Lord Christ, and to exterminate the living God. Similar latent motives have always been imputed to the fraternity, and it seems quite unnecessary to disclaim them, since their own minds are entirely preassured of the safety of Deity.

Now, sneers, innuendoes, and glittering generalities, may be convenient weapons with which to assail unwelcome arguments and conclusions, but they are certainly very ineffective. Such opposition will never end the controversy. The very animus of Protestantism is investigation, and shall New England Christians ally themselves with the pope in endeavoring to suppress its processes and ignore its results? It is only the new truth, the latest discovery, the undeveloped scheme, that is thus assailed and abused. After it has stood before the world a few decades—some other startling thought having in the mean time stepped to the front—it quietly takes its place among established facts or principles, Biblical interpretations adjust themselves, and its exponents, living or dead, are duly applauded and honored. A long catalogue of names might be cited in illustration, including, besides many scientists, some of the noblest reformers, whose diaries record every shade of treatment from their contemporaries, from the most virulent abuse to cordial recognition. What name stands fairer to-day than that of William Lloyd Garrison? And what living man has been more defamed and reviled than was he while he stood in advance of public sentiment on the question of slavery? In the eyes of the American churches it was *their* "peculiar institution" which he was covertly attacking, making only a blind of the great Southern evil which his soul abhorred. All the familiar idioms of the sects were liberally used in his behalf, and he was "throttled" in Boston with something more tangible than rhetoric.

So the fanatics and infidels of one generation become the heroes and philanthropists of the next.

The Concord clique of philosophers has been in past years most bitterly denounced in orthodox circles, and the patriotic old town itself has been called "the hot-bed of moral poison," and various other names equally expressive of the temper of their originators. But now, the leader and exemplar of that radical coterie, the revered and beloved Emerson, lectures acceptably before the theological students of Andover Seminary, while its chapel pulpit has recently been occupied by a prominent Unitarian clergyman, who, thirty years since, would have been shunned by the Faculty as a teacher of dangerous and pernicious doctrine.

Agassiz was no less a truth-seeker, his spirit was no less reverent, his purpose no less pure, when he broached his unscriptural theory, than when he bowed his head in silent worship at the opening of the Penikese School. Now, when the year returns, and he returns no more, we could almost canonize his memory. But why was he anathematized a quarter of a century ago? Simply because his position at that time represented the flood-mark of scientific investigation. It has changed place since then, and Tyndall now stands at its level, and must bear the surging of every tide.

Nothing is more acceptable to the honest thinker than intelligent criticism. Matthew Arnold said ten years ago that it was the great want of Europe. Worthy antagonism is always a valuable auxiliary in the cause of truth. Under its eye, eloquence is not allowed to pass for evidence, nor assertion for argument. It stimulates and reënforces the scholar, and extinguishes the pedant. It tends to prevent men from becoming so ardently in love with their own theories as to be blind to their defects. If it is able, as at the best it is, to set in motion a counter-current of thought, clear and forcible, it has attained its highest uses and becomes a real power. But the mind of the critic should be to the thought before it as the plane-mirror, reflecting it in true colors and exact proportions; otherwise, instead of just criticism, there follows either too liberal indorsement or undue stricture, according to the bias of the writer.

Thus adequately to examine the scientific positions of the day, with a view of supplementing or subverting them, requires an amount of special preparation which few who have worked in other fields of thought have been able to make; for a certain familiarity with scientific nomenclature and experiment, which is often acquired collaterally by the good student, though of great interest and value to its possessor, is not a reasonable basis for revision of principles, methods, and deductions. The arts are all closely akin, and Sir Joshua Reynolds was a fine connoisseur in his own department, and perhaps, like Titania's transient love, he had "a reasonable good ear in music;" but he probably could not have written a competent *critique* on the

construction of Bach's fugues, or supplied the missing harmony to the original score of the "Messiah." For a correct exegesis of the Apocalypse, or the Book of Job, we should not go to the scientist, but to the trained and acute Biblicist; and when our thoughts are turned toward the sources and interpretations of natural phenomena, to whom shall we look for direction and guidance, but to those who have made these phenomena their life-long study? "Every one for his own."

If the destruction of these more recent theories, or their immediate and unreserved acceptance, were our only alternative, there might be some excuse for attacking them, even with the very unsuitable and impotent weapons with which most of us are furnished. But why can we not suffer ourselves to "make haste slowly" in regard to these questions which are so difficult, and, in a certain sense, so remote? The most enlightened scientists hold their views not rigidly, but flexibly, expecting them to undergo various modifications, as truth is gradually unsealed and error eliminated. They invite both scrutiny and correction; and, when argument is met by argument, proof with counter-proof, when premises are shown to be false, methods insufficient, or inferences illogical, none are more ready and generous in acknowledgment of mistakes. The absence of assertion is particularly noticeable in their writings. Their opinions are frequently prefaced with such phrases as "So far as I can discover," "Is it not probable," "Are we not justified in believing;" thus appealing to the intelligence and discernment of the reader, instead of seeming to compel his acquiescence. Darwin's first words in the second volume of the "Descent of Man" are, "I have fallen into a serious and unfortunate error;" and he frankly states that his explanation of certain coincidences is wholly erroneous. Does this candid admission detract from his general trustworthiness? Certainly not, to the equally candid reader. In summing up the main conclusions at the close of this elaborate work, he alludes to the still higher destiny which man may hope for in the distant future; but he instantly checks the incipient speculation with the characteristic utterance of the true devotee of science: "But we are not here concerned with hopes or fears, only with the truth as far as our reason allows us to discover it. I have given the evidence to the best of my ability."

These untiring students ask only unrestricted right of search and freedom of discussion. Shall this modest request be practically denied them? Shall the weak timidity and the unreasoning hostility of the sixteenth century forever repeat themselves in the presence of a fresh idea? Verily, a stranger in the world of thought fares hard at our hands. We are forgetful to entertain it until its wings appear, and that is not Scriptural hospitality.

Tyndall beautifully says: "Science desires not isolation, but freely combines with every effort toward the bettering of man's estate. The lifting of the life is the essential point." Are the sarcasms of the

preacher an effort in the same direction? Will his animadversions tend to make his hearers more charitable in their judgments of others? Will his sneers at an opinion which differs from his own be likely to raise the standard of tolerance and Christian courtesy? Is a leaning toward the belief that matter contains the promise and potency of all terrestrial life, incompatible with the ordering of the individual life in accordance with high-toned Christian principles? Or will the rejection of the Darwinian theory be sure to free us from prejudice and cheap ambitions?

An excellent tonic, for a mind that is weary of this constant challenging of leading scientists to unequal contest, is one of their own "Lay Sermons." In reading their literature, one soon passes into an atmosphere which admits no element of petty strife. Their spirits are finely touched to fine issues, and they seem to have attained that splendor of expression which, Emerson says, carries with it the proof of great thoughts. Byron's "Corsair" left a name "linked to one virtue and a thousand crimes;" and perhaps even the pope would allow to these spiritual types of the same order the one virtue of an almost faultless style. It is not splendor of imagery, or mere ornament of any kind, that gives it its peculiar charm. It is the beauty of exquisite fitness, of perfect adaptation. Language seems sensitive to the fervor of their thought, and yields to them all its wonderful vividness. Let us not be withheld by fear, by the restraints of inherited conservatism not yet outgrown, or by misdirected pulpit influence, from studying the pages of any book, magazine, pamphlet, or newspaper, containing the selected thoughts of scientists, carefully prepared for the general reader. They furnish some of the best material for daily consideration and conversation. We find in them a centre and sequence of thought, and a natural cohesion of parts, which favorably distinguish them from many popular productions, both written and spoken. They not only show us facts, they teach us to generalize from such data, and to put a proper relative value upon different ideas. They give us a clearer vision and an ampler horizon. They quicken the perceptions, mature the judgment, and purify the taste. And if, in his enthusiasm, a writer sometimes ventures beyond the limits of verified evidence, and gives one touch of imaginative coloring to the sober shades of reason and argument, can we not bear with it, when we remember with what infinite patience the world has for ages listened to baseless and useless conjectures, and sentimental fancies concerning heaven, its conditions, employments, and delights?

We are called to no decision upon these great questions, but let us study them, and draw from them all possible mental stimulus and moral force, and then be sure to give our personal influence in support of our highest convictions. The verdict rests with Time, and we know that under its slow, sure touch, all error must fall away, leaving Truth triumphant in the strength of her own immortality.

SOCIAL EVOLUTION.

By Prof. J. E. CAIRNES.[1]

ANXIOUS as all who take an interest in social speculation cannot fail to be for the completion of Mr. Spencer's forthcoming work on the "Principles of Sociology," they will scarcely regret that he should have allowed himself to be drawn aside for a time from his principal occupation in order to compose the present volume. Several reasons concur to make it desirable that such an *avant-coureur* should be sent forth; but it is sufficient here to mention one. With every possible disposition to acknowledge the great services of M. Comte in his masterly *ébauche* and partial development of the science of society, it is impossible not to see that even the elementary principles of this branch of inquiry have yet to be formulated. To constitute these, or at least some portion of them, is doubtless the aim of Mr. Spencer's grand undertaking. It is to this that the labors of his life have been leading up; but, if his work is to prove in any sense definitive, it is plainly an indispensable condition that it should be preceded by a tolerably full and thorough discussion of the more elementary doctrines of the new science. Mr. Spencer has not, indeed, waited till now to give the world his ideas on many social topics of the highest importance; but it was well thus to bring together into a single volume his sociological views scattered over many essays, and, by giving them fresh exposition and illustration, to invite fresh criticism. Never before has the conception of a social science been put forth with equal distinctness and clearness; and never has its claim to take rank as a recognized branch of scientific investigation been placed upon surer grounds, or asserted with more just emphasis. The wealth of illustration lavished on the various topics discussed is almost marvelous; and, when one considers that Mr. Spencer has already on hand a great work on the same subject, augurs a rare profusion of resources. The purpose of the present essay, however, is not to render to Mr. Spencer a homage of which he has no need, but to invite attention to some positions of his philosophical system, so far as it has been given to the public, which have scarcely yet received that amount of consideration and criticism which their great importance demands. As will be seen, and indeed has already appeared, the following remarks have been conceived from the point of view of one who fully accepts the possibility of a social science, and who, to a large extent, concurs in Mr. Spencer's conception of the nature of that inquiry.

The part of Mr. Spencer's social philosophy to which he has hitherto given most prominence, and which he has elaborated with most care, is his doctrine of Social Evolution. The idea was put forward

[1] A review of "The Study of Sociology," by Herbert Spencer. D. Appleton & Co.

by him, many years ago, in a well-known essay entitled the "Social Organism;" it has since received further elucidation in a discussion with Prof. Huxley in this *Review;* and it has once more been expounded anew, and with fresh illustration, in the present volume. There is a certain sense in which, I presume, the doctrine of "Social Evolution" would be now pretty widely accepted, at least among those who have concerned themselves with the philosophy of history and kindred speculations. I mean the sense in which it expresses the fact that each stage in human progress is the outcome and result of the stage which has immediately preceded it, and that the whole series of stages, beginning with savage life and ending with the most advanced existing civilization, represents a connected chain, of which the links are bound together as sequences, in precisely the same way as in the instances of causation presented by other departments of Nature. Some such assumption as this must necessarily form the basis of all attempts at a rational interpretation of history. But, as enunciated and expounded by Mr. Spencer, social evolution carries with it a meaning much more precise and significant. As his readers are aware, Mr. Spencer insists very strongly on the analogy of evolution, as exhibited in the animal kingdom, whether in the individual animal or in the species, and evolution in human society—in other words, between the development, individual and specific, of the animal organism, and the development of what he calls "the social organism," meaning, thereby, organized social life. He finds in this analogy not merely a metaphor and an illustration, but a type, and even a clew. Thus he observes a law of development governing the growth of an individual organism from birth to maturity; and, again, a similar law governing the development of species from existence in an all but amorphous germ to the attainment of a very high and complex form of animal life; and he transfers these laws from physiology and zoology to the domain of social science; treating them not merely as the means of elucidating social phenomena, but as exhibiting the real character of the processes by which mankind have in fact attained their present civilization, and as foreshadowing, also, the lines along which society in its future development is destined to move. It is, for instance, a characteristic of the evolution of individual organisms under the laws of animal growth, as well as of that of the several species of animals under the influence of the struggle for existence and the law of the "survival of the fittest," that development takes place "spontaneously"—that is to say, is the *incidental result of actions not consciously undertaken with that object in view.* This is evidently so in the growth of an individual animal, and it is no less certainly so in the development of species. In neither case is the progress attained the result of efforts consciously put forth for its accomplishment. And the whole drift of Mr. Spencer's teaching on this subject is to show that the process is similar in the case of human society; that its growth and development

are in no degree, or at all events in quite an insignificant degree, the consequence of efforts put forth by those who compose it to improve their social condition, but mainly, if not exclusively, the result of actions undertaken with quite other ends in view. A favorite illustration, accordingly, with Mr. Spencer of the process by which society undergoes development is the growth of language:

"Not only has it been natural from the beginning, but it has been spontaneous. No language is a cunningly-devised scheme of a ruler or body of legislators. There is no council of savages to invent the parts of speech, and decide on what principles they should be used. Nay, more. Going on without any authority or appointed regulation, this natural process went on without any man observing that it was going on. Solely under pressure of the need for communicating their ideas and feelings, solely in pursuit of their personal interests, men little by little developed speech in absolute unconsciousness that they were doing any thing more than pursuing their personal interests." (Essays, vol. iii., p. 129.)

And this is given as a typical specimen of the "workings-out of sociological processes"—of the marvelous results "indirectly and unintentionally achieved by the coöperation of men who are severally pursuing their private ends." The numerous and complex arrangements which, under the stimulus of individual self-interest, have arisen in this and other civilized countries for the distribution of wealth, and the growth from small beginnings of our vast system of credit and banking, serve as an illustration of the same principle. "When it is questioned," he remarks, "whether the spontaneous coöperation of men in pursuit of personal benefits will adequately work out the general good, we may get guidance for judgment by comparing the results;" and he proceeds to give examples which could only lead to an affirmative conclusion.

The nature of social development is thus, according to Mr. Spencer, essentially identical with that of development in the animal kingdom; and it is a necessary corollary from this that the course of both should lie along parallel lines. Thus, when we find the individual animal growing from birth to maturity, developing its structure and functions according to a regular scheme; and, similarly, the several species of animals constantly tending, under the influence of the struggle for existence, to adapt themselves more and more perfectly to the conditions of their environment, and so to rise into a higher and higher order of being; when we find all this, and perceive that the processes by which society is developed are exactly analogous, the conclusion seems inevitable that so it must be also with social evolution—that here, too, progress and improvement arise by way of spontaneous growth in the natural order of things, and that consequently efforts to advance the common interest are superfluous—much more likely, in effect, to impede and disturb than to assist the harmonious order of human development.

Such, so far as I have been able to extract his meaning from his

various essays on this subject, is Mr. Spencer's theory of social evolution. The practical effect of such a doctrine on all engaged in helping forward, according to the measure of their strength, the cause of human well-being, it is not difficult to perceive; nor does Mr. Spencer altogether blink this aspect of the case. In the last two pages of his recent work he has the following remarks:

"If, as seems likely, some should propose to draw the seemingly awkward corollary, that it matters not what we believe, or what we teach, since the process of social evolution will take its own course in spite of us; I reply that, while this corollary is in one sense true, it is in another sense untrue. Doubtless, from all that has been said, it follows that, supposing surrounding conditions continue the same, the evolution of a society cannot be in any essential way diverted from its general course; though it also follows (and here the corollary is at fault) that the thoughts and actions of individuals, being natural factors that arise in the course of the evolution itself, and aid in further advancing it, cannot be dispensed with, but must be severally valued as increments of the aggregate force producing change."

Whether this explanation will be satisfactory to those who draw the "seemingly awkward corollary," may, perhaps, be doubted. Mr. Spencer apparently does not rely much on the practical efficacy of his answer, for he at once proceeds to supplement it as follows:

"Though the process of social evolution is, in its general character, so far predetermined that its successive stages cannot be antedated, and that hence no teaching or policy can advance it beyond a certain normal rate, which is limited by the rate of organic modification in human beings, yet it is quite possible to perturb, to retard, or to disorder the process. The analogy of individual development again serves us. The unfolding of an organism after its special type has its approximately-uniform course, taking its tolerably-definite time, and no treatment that may be devised will fundamentally change or greatly accelerate these; the best that can be done is to maintain the required favorable conditions. But it is quite easy to adopt a treatment which shall dwarf, or deform, or otherwise injure; the processes of growth and development may be, and very often are, hindered and deranged, though they cannot be artificially bettered. Similarly with the social organism."

If I am not mistaken, however, the case of the social organism is not similar. The favorable conditions which it is important to maintain with reference to the individual organism are conditions external to the organism; whereas that condition of social development, the efficacy of which forms the question in dispute, consists in efforts after social improvement made by the units composing the organism. The analogy, therefore, of individual development completely fails us here, unless, indeed, Mr. Spencer supposes the objectors he is addressing to be standing outside the social organism, and proposing to experiment upon it as upon a foreign body. But, not to dwell on this point, the conclusion arrived at is that, "by maintaining favorable conditions, there cannot be more good done than that of letting social progress go on unhindered;" whereas "an immensity of mischief may be

done in the way of disturbing and distorting and repressing, by policies carried out in pursuit of erroneous conceptions." Indifferent comfort, this, for the friends of humanity; but it is all Mr. Spencer has to offer. He adds "a few words," however, "to those who think these general conclusions discouraging. Probably the more enthusiastic, hopeful of great ameliorations in the state of mankind, to be brought about rapidly by propagating this belief or initiating that reform, will feel that a doctrine negativing their sanguine expectations takes away much of the stimulus to exertion. If large advances in human welfare can come only in the slow process of things, *which will inevitably bring them*, why should we trouble ourselves?" A very natural question. And what is Mr. Spencer's answer? Simply that on visionary hopes rational criticisms cannot but have a depressing influence. But "it is better," he adds, "to recognize the truth."

Doubtless "it is better to recognize the truth;" but before accepting as true a doctrine admittedly so depressing, carrying with it such "seemingly awkward corollaries," it will, at least, be well to subject it to a somewhat careful examination. And, in the first place, there is this remark to be made, that no verification whatever has yet been offered, or, so far as I know, attempted, of the theory of social evolution set forth with so much appearance of scientific authority. It represents a speculation transferred from the domain of physiology and zoology into that of social inquiry, and the speculation, so transferred, is applied, without question or scruple, to the interpretation of human affairs; no attempt having been made to ascertain how far the course of these affairs hitherto has corresponded with the doctrine thus formulated. The range of human history now covers upward of 3,000 years, and presents, in a very incomplete and imperfect manner, no doubt, the phenomena of moral, intellectual, religious, and other evolution in numerous societies of men. Surely, before propounding his speculation as a law of human society, from which he is at once justified in deducing consequences of the largest kind bearing upon human conduct, Mr. Spencer was bound to consider what amount of countenance or support it received from the evidence derivable from such fields of research; but from the application of this test he has wholly abstained. Will it be said that our knowledge of past history is so exceedingly slight and untrustworthy as to be unfit to furnish a datum for social speculation, and that verification had thus to be dispensed with as impracticable? Such a defense, it seems to me, is scarcely available in the present instance; for, while it is true that about particular events in history there is, in general, much room for doubt and for difference of opinion, this is not the case, or is in a very slight degree the case, with regard to certain broad generalizations which come out with considerable distinctness from the study of the past, and which are, in effect, the very generalizations needed in order

to test Mr. Spencer's doctrine. Thus there cannot be much doubt that certain nations have, during certain centuries of their history, made rather rapid progress in civilization, but have afterward suffered an arrest, which has, in some instances, been followed by temporary or permanent decline; while, on the other hand, others, and these by far the more numerous, have continued for thousands of years in a condition almost, if not altogether, stationary. In his work on "Ancient Law," Sir H. Maine does not hesitate to say that—

> "The stationary condition of the human race is the rule; the progressive, the exception." "In spite of overwhelming evidence," he remarks, "it is most difficult for a citizen of Western Europe to bring thoroughly home to himself the truth that the civilization which surrounds him is a rare exception in the history of the world. . . . It is indisputable that much the greatest part of mankind has never shown a particle of desire that its civil institutions should be improved, since the moment when external completeness was first given to them by their embodiment in some permanent record."

Again, it is a point upon which, I suppose, it may be said, historians are agreed, that, even in Europe for many centuries—starting, let us say, from the age of the Antonines, and ending with the eleventh or twelfth century—the movement in human affairs was on the whole steadily backward; the state of things existing at the latter date being, according to all the main tests of human well-being, far in arrear of the condition attained in the former epoch. It may be that these generalizations are superficial, that the learning of the world is here at fault, and that history better understood would support Mr. Spencer's view; or it may be that the current beliefs on the points in question are capable of being reconciled with the new doctrine. Be this as it may, it is not the less true that the verdict of history, as now understood by its most competent interpreters, is distinctly opposed to the theory of social evolution enunciated by Mr. Spencer. Now, this is a fact which has been completely ignored by that distinguished writer; he has simply passed it by as not concerning his argument; and in doing so has, as I contend, set at naught one of the best-understood canons of the inductive method—the canon that requires that hypotheses, before being accepted as laws of Nature, or made the bases of confident deduction, should be carefully verified by comparison with all available facts pertinent to the question in hand. M. Comte, who, as regards the particular point under consideration—the *necessarily progressive* character of human evolution—is at one with Mr. Spencer, understood otherwise the claims of the positive philosophy, and does, in fact, fairly attempt to grapple with the historical difficulties to which I have referred. It is true, indeed, his argument is by no means successful—at least so it seems to me—in establishing the required conclusion; but it is, at least, more satisfactory than total silence.

It follows, then, that Mr. Spencer's theory of social evolution can only be regarded, as matters now stand, as an unverified hypothesis,

with this presumption against it, that it is at variance with such knowledge as we possess of the past history of mankind; and the doubt as to its soundness, which this circumstance cannot but suggest, will, I think, find confirmation, when we look closely into that analogy between the social and the animal organisms *on which the whole speculation is built up.* In the striking and ingenious essay in which Mr. Spencer first traced this analogy he frankly admits that it does not run on all-fours, and he enumerates no less than four points in which the analogy fails. There will be no need at present to refer to more than one of these: it is to the effect that, unlike the sentient life of animals, which is concentrated in the brain, the sentient life of societies is diffused equally over the entire surface—

"A fact," says Mr. Spencer, "which reminds us that, while in individual bodies the welfare of all other parts is rightly subservient to the nervous system, whose pleasurable or painful activities make up the good or evil of life, in bodies politic the same thing does not hold, or holds but to a very slight extent. It is well that the lives of all parts of an animal should be merged in the life of the whole; because the whole has a corporate consciousness capable of happiness or misery. But it is not so with a society; since its living units do not and cannot lose individual consciousness, and since the community as a whole has no corporate consciousness. And this is an everlasting reason why the welfare of citizens cannot rightly be sacrificed to some supposed benefit of the state, but why, on the other hand, the state is to be maintained solely for the benefit of citizens. The corporate life must here be subservient to the lives of the parts, instead of the lives of the parts being subservient to the corporate life."

I have called attention to this admission because it appears to me to involve very much larger consequences than Mr. Spencer seems disposed to allow—consequences, if I mistake not, fatal to this theory. For what does it amount to? To this, that, however closely the two organisms he has been comparing may correspond in certain details of structure and function, the main purposes of the two schemes—the ends for which alone all the contrivances exist, and with reference to which their goodness or badness must be judged—are essentially different; the aim of the one being to sustain the corporate existence, and to contribute to the corporate happiness; while that of the other can properly have regard only to the existence and happiness of the individual elements which compose it. This being so, what can be more preposterous than to erect the modes of organization furnished by the animal kingdom into patterns and exemplars by which to regulate the relations of social life? What does such doctrine come to but a proposal deliberately to sacrifice the substance to the shadow—the ends of social existence to the establishment of a fanciful analogy? The reader of Prof. Huxley's essay on "Administrative Nihilism" will probably remember the passage in which he turns the analogy in question against Mr. Spencer, and converts it into an argument in favor of extending the functions of the state, or rather shows how it might be thus converted:

"The fact is," says Prof. Huxley, "that the sovereign power of the body thinks for the physiological organism, acts for it, and rules the individual components with a rod of iron. . . . The questioning of his authority involves death, or that partial death which we call paralysis. Hence, if the analogy of the body politic with the body physiological counts for any thing, it seems to me to be in favor of a much larger amount of governmental interference than exists at present, or that I, for one, at all desire to see. But, tempting as the opportunity is, I am not disposed to build up any argument in favor of my own case upon this analogy, curious, interesting, and in many respects close as it is, for it takes no cognizance of certain profound and essential differences between the physiological and political bodies."

And Prof. Huxley proceeds to point out one of those profound and essential differences, which, if the reader will refer to his argument, will be seen to come, in effect, to very much what Mr. Spencer himself had admitted, in his original essay, in the passage which I have quoted. As the reader is probably aware, Mr. Spencer replied to Prof. Huxley's attack in an elaborate article, now printed in the third series of his collected essays; but, though he might have claimed to have anticipated the objection urged against him by pointing to the passage in which the failure of the analogy in the circumstance in question was admitted and even insisted on, he did not take this course. In truth, though he might thus have avoided the *reductio ad absurdum* with which he was pressed by Prof. Huxley, and might also have saved his own consistency, he could only have done so by the entire surrender of his main position; for he must have admitted that the all-sufficing analogy, "curious, interesting, and in many respects close" as no doubt it is, was yet, for the purpose of political argument, entirely destitute of cogency; and this was an admission which Mr. Spencer did not see his way to make.

It may still, however, be contended that, though of small account as a criterion in practical politics—in the sphere of what we may call the statics of sociology—this analogy between the individual and social organisms may nevertheless possess value in reference to the dynamical aspects of the social problem, as throwing light, that is to say, on the course of social evolution. And such, it appears to me, is the case so long as we confine ourselves to a very primitive stage in the social history of man. In that primitive stage (as Mr. Darwin has taught us), while man remains still a savage, and even perhaps for some time after he has emerged from the savage condition, the influences which mould his social development are substantially the same with those which govern the development of a species. It is not strange, therefore, that evolution in the human and in the animal kingdom should, during this period, follow a very similar course. But a time arrives in the progress of social development when societies of men become conscious of a corporate existence, and when the improvement of the conditions of this existence becomes for them an object of conscious and deliberate effort. At what particular stage in

human history this new social force comes into play, we have no need here to inquire. What I am concerned to point out is that *it is a new social force*, wholly different in character from any which had hitherto helped to shape human destiny—wholly different, also, from those influences which have guided the unfolding either of the individual animal or of the species. We cannot, by taking thought, add a cubit to our stature. The species, in undergoing the process of improvement, is wholly unconscious of the influences that are determining its career. It is not so with human evolution. Civilized mankind are aware of the changes taking place in their social conditions, and do consciously and deliberately take measures for its improvement.—*Fortnightly Review.*

SKETCH OF DR. HENRY MAUDSLEY.

THOSE who are familiar with the growing literature of psychological medicine during the last quarter of a century will remember the appearance of various papers remarkable for literary brilliancy and expressive of the most advanced opinion which appeared, nearly twenty years ago, in the English periodicals devoted to this subject, and written by Dr. Henry Maudsley. He was then a very young man, and the promise of his early efforts has been thoroughly redeemed by his subsequent professional career. A voluminous and able writer, and an eminent practitioner, he is now among the foremost men in the branch of medicine to which he has devoted himself. The last quarter of a century has witnessed a great change in the mode of studying mental phenomena. The old metaphysical method, which confined itself mainly to introspection of consciousness, with no more regard to the organic conditions under which mind is manifested than as if such conditions had no existence, has been invaded, and perhaps it is not too much to say, as a method of study, has completely broken down. Not that the introversive study of the phenomena of consciousness has been abandoned, but its sufficiency has been completely discredited; and mental science takes a new departure with the recognition that its organic basis is a fundamental element in its problems. The physicians whose studies begin with the body and traverse the field both of its normal and abnormal states, were forced to consider the subject of mind from the corporeal side, and with reference to the exigencies of practice. Metaphysical speculation was fruitless for their purposes; the mind had to be considered as dependent upon material conditions. The new order of truths thus brought forward has had a profound influence upon recent mental philosophy, and, in this reconstruction and reëxposition of the science, the subject of the present sketch has had a prominent share. His contributions to the literature

of the question have not only been valuable acquisitions to the profession, but they have also been well adapted for the diffusion of this kind of knowledge among general readers.

HENRY MAUDSLEY was born at Rome, near Settle, in Yorkshire, in 1835, and is, consequently, now but forty years of age. When his early academic studies were completed he chose the profession of a physician as a vocation, and entered upon the study of medicine at University College, London. His career as a medical student was eminently successful, and he obtained the highest honors in the different classes, and graduated M. D. at the University of London in 1856, at twenty-one years of age, having also obtained a scholarship, with the title of "University Medical Scholar." Selecting mental pathology as his medical specialty, he became resident physician and superintendent of the Manchester Royal Lunatic Hospital, a position which he held from 1859 to 1862. Resigning this appointment in 1862, he yielded to the temptations of the metropolis, and entered on a consulting practice in London. The speedy recognition of his professional claims led to his election as Fellow of the Royal College of Physicians in 1869, and the next year he had the honor of an appointment as Gulstonian Lecturer. Dr. Maudsley is Professor of Medical Jurisprudence in University College, London, and Consulting Physician to the West London Hospital. He has been President of the Medico-Psychological Association of Great Britain and Ireland, and is now, as he has been for some years, editor of that able periodical, the *Journal of Mental Science*. His labors have been appreciated on the Continent, and he has been elected Honorary Member of the Medico-Psychological Society of Paris, and of the Imperial Society of Physicians of Vienna, etc.

Dr. Maudsley's most important work is "The Physiology and Pathology of Mind," a standard treatise for the profession, and a repertory of interesting facts—an able exposition of mental phenomena in their organic relations. This work has passed through several editions, as has also the lesser volume which he subsequently issued, "The Gulstonian Lectures on Body and Mind." His contributions to the *Journal of Mental Science* have been numerous and important; and his last work, "Responsibility in Mental Disease," written for the "International Scientific Series," is an important monograph which has been widely read, and has contributed to extend the author's reputation.

Dr. Maudsley married the youngest daughter of the late Dr. John Conolly, whose name has been made eminent as the physician who first introduced into England, and carried out successfully, at Hanwell, that great reform, the non-restraint system in the management of lunatics.

CORRESPONDENCE.

THE FUTURE RELATIONS OF THE SEXES.

To the Editor of the Popular Science Monthly:

IN the article on "Woman's Place in Nature," which appeared in the January number of THE POPULAR SCIENCE MONTHLY, some applications of the general principles enunciated were omitted for the sake of brevity, and, deeming them important, I send them for publication, in continuation of that argument.

Although the characters peculiar to each sex have undoubtedly been acquired under the operation of the same laws, it would seem that men and women have become too much differentiated in their mode of living, for the physical or mental health of either. Among lower animals in a wild state, sex makes little difference in the habits of life; and, among barbarous tribes and races of men, there is little concerted action or differentiation of duties of men and women, except in the conduct of wars of rivalry or defense; and it has always been considered a sign of a higher civilization when woman is released from the heavier kinds of labor, and relegated to a special and different sphere of activity. But civilization, even, may be carried too far, in the extreme separation of men and women in their daily lives, no less than in the generally-acknowledged direction of the excessive refinements of metropolitan life; and there seems to be a tendency to a "reversion" in this respect, in an increasing disposition on the part of women to share, to a fuller extent than heretofore, the labors, the interests, the education, and the recreations, which do so much to give physical health and mental vigor to men. On the other hand, the sexual erethism, amounting to a pathological condition, so frequent among the men of to-day, may be regarded as an indication in the same direction. The greater strength of sexual passions in men is looked upon as a weakness and degradation by women—the "social evil" being largely attributed to it as a cause. While the brief review of the causes and conditions of the development of the race, given in a former article, shows, if both facts and deductions are accepted, that the higher traits of human character have arisen largely through this inequality, the fact of its having become excessive may be taken as an indication of the desirableness of a "reversion" for men as well as women; and, through a more intimate association in business relations, where the affinities of sex would be less powerfully asserted among sterner interests—where mere entertainment of each other would not be the occupation of the hour, as in social gatherings and dissipations—it is probable that a tendency would arise toward an equalizing of the sexes in this particular, which would contribute to the health of both; and that co-education, though advocated in the interests of women only, would result in advantage to both sexes.

An undue accumulation of electric force terminates in the thunder-bolt, which carries disaster in its pathway; while a more constant communication between cloud and earth tends to the maintenance of a safe equilibrium, by which means catastrophe is averted, and a better atmospheric condition secured.

While it would not be in accordance with the principles of evolution to say that woman does not now occupy her true and natural place in life, the fact of her increasing dissatisfaction with it is evidence that she is moving on to a better one—better, because higher in the scale of evolution. Says Lecky: "That the pursuits and education of women will be considerably altered, and that these alterations will bring with them some modifications of the type of character, may safely be predicted."

Since it is in the direction of greater moral as well as intellectual unfolding that the future progress of the race is undoubtedly to consist, woman will find ample fields for the expenditure of her special force and influence. I would not be understood to discourage women from entering any profession or department of labor to which

they may feel themselves called. While thus developing their individual powers, it is probable that all the industries and activities of life would also be bettered by the introduction into their management of the spirit of "greater tenderness and less selfishness" which it would seem that heredity and selection have bestowed upon her. Our courts of law are often characterized by scenes of harshness, and brutality even; and surely the professions of theology and medicine furnish fitting fields for the exercise and culture of these beneficent qualities. Without doubt the possession of these traits, in a somewhat higher degree, by woman than by man, will counterbalance her disabilities in other directions, so that, in the struggle for success, she will suffer no serious disadvantage.

While intellectual arenas may always furnish a neutral ground where the two sexes shall meet on the common basis of actual achievement—where all work shall be submitted to the common test of merit—in matters of general interest to society, qualities essentially masculine on the one hand, or peculiarly feminine on the other, will turn the balance of power according as the interests or necessities of the hour are best subserved thereby. The existence of war would seem to furnish an extreme case in which masculine traits would be in the ascendant, and receive supreme consideration; but the hospital and the ambulance—the sanitary commission and the nurses' field-staff—present the converse of the picture, where feminine qualities assert their natural supremacy. On the other hand, "the instinct and genius for charity," ascribed to woman, find their executive force in the masculine arm, always at her command in carrying out her most generous conceptions.

Thus the contrasting phases of human nature meet and blend, like the forces at the opposite extremes of the spectrum, which, presenting the unlike characteristics of heat and actinism, unite in the visible middle ground, and speak in the beautiful language of color. Unrefracted, the full white ray of perfect light is manifested as a unit.

Solicitude is sometimes expressed lest an enlargement of the activities of woman, and the consequent mingling in the ruder scenes of life, should impair the delicacy and refinement which belong to womanhood; but this would seem to be a needless anxiety. Traits of character so inwoven in the very fibre of the nature as those which distinguish the sexes will not be easily eradicated, and the same laws which are now at work to check the too great differentiation of both in the direction in which they have hitherto tended, will prevent any excess of reaction. In this imperfect review of a subject commensurate with the history of the human race, at least, and generally believed to extend its rootlets to the lowest grades of organic life, we have seen that the key to the history of the evolution of the race lies in the distinction of sex.

This distinction, making its appearance at the very threshold of development of organized structures, *pari passu* becomes more marked and intricate with increased complexity of form and function, till perfect dualism is reached and exemplified in man, the crowning result of creation by evolution.

Its two phases, male and female, are not opposed in the sense of being antagonistic, but complementary rather, and so related that each finds development only in and through the other.

In the eloquent language of Roehsig—"The law of polarity, which applies seemingly to all inorganic Nature and controls the realm of life, gains its crowning efflorescence in the distinction of sex, and asserts its dominion over the operations of mind itself."

FRANCES EMILY WHITE, M. D.

PHILADELPHIA, *January* 20, 1875.

EDITOR'S TABLE.

CAIRNES ON SOCIAL EVOLUTION.

IN an elaborate article contributed to the January *Fortnightly Review*, Prof. Cairnes has attacked the social philosophy of Herbert Spencer. The paper is too long to be wholly transferred to our pages, and so we reprint the first half; but that, it happens, is the most important part, and a little examination of its quality will show that not much has been lost by omitting the remainder. Coming from the source it does, we read the article with not a little surprise, for its writer either has no clear understanding of his subject, or he is trifling with it in a very inexcusable way. The subject is undoubtedly an important one, and is entitled to be considered with the utmost intelligence and candor. The *Saturday Review* tells us that "Englishmen hate men who offer them new ideas." This may be extravagant, but if it had said they hate men who offer them new ideas *upon social topics* it would probably have been nearer the truth. Social science implies that there are great natural agencies by which society in the past has been developed, and by which it is still largely regulated; but, of all people in the world, the English should be the least sympathetic with such a view, for nowhere else has Nature been more overlaid and buried out of sight by human arts, arrangements, and conventions, than in that country. But, whether under a patriotic bias or not, Prof. Cairnes is at no pains to conceal his dislike of Spencer's social doctrines. As a politician and a philanthropist enlisted in the service of humanity, he takes ground against their general influence. From this point of view he opposes Mr. Spencer to Mr. Mill as follows:

"On the one hand there is the philosophy of Mr. Spencer contemplating the career of humanity as fixed with regard to its main direction, as predetermined to move along certain defined or at least definable lines of progress, constantly shaping itself under the influence of causes which produce their effects spontaneously. . . . Can we have any doubt as to the tendency of such teaching? As to its paralyzing effect on laborers in the field of human improvement? . . . Contrast with this the teaching of that other philosophy with which Mr. Spencer's has been confronted in this discussion—the philosophy of Mr. Mill, every line of whose writings is instinct with the belief that there is nothing fixed in human fortunes—that it rests with the individual men and women of each generation as they pass, each within the range of his or her influence, to make or to mar them—whose creed it is that social progress is largely dependent on political institutions, which do not 'grow' while men sleep, but 'are the work of men—owe their origin and their whole existence to human will.'" Now, all that Prof. Cairnes can make by this contrast, he makes, not against any special system of sociological doctrine, but against the conception of natural law in social affairs; and yet he admits that the very creation of the social state is the work of spontaneous natural forces, such as have produced the diversities of life. He says: "In that primitive stage (as Mr. Darwin has taught us) while man remained still a savage, and even perhaps for some time after he is emerged from the savage condition, the influences which mould his social development are substantially the same with those that govern the develop-

ment of a species." Again, he admits that "each stage in human progress is the outcome and result of the stage which has immediately preceded it, and that the whole series of stages, beginning with savage life and ending with the most advanced existing civilization, represents a connected chain, of which the links are bound together as sequences in precisely the same way as in the instances of causation presented by other departments of Nature. Some such assumption as this must necessarily form the basis of all attempts at a rational interpretation of history." But if Prof. Cairnes (without damping his reformatory ardor) can hold that society is bound in the chains of causation like "other departments of Nature," why should other laborers in the field of human improvement be paralyzed? If the holding of a belief in the utmost fatalism of law in social affairs is not sufficient to clip the wings or trip the heels of Prof. Cairnes's philanthropy, wherefore should Mr. Spencer be depressed, who avows no such extreme views? The effect, indeed, ought to be rather the contrary, for Prof. Cairnes maintains that his chain of causation, which is dragging the world's events along, is not raising or improving them, which would seem to be rather a gloomy reflection; while, on the other hand, Mr. Spencer holds that the great and irresistible tendency of things is toward a higher and better state, a view which is fitted to inspire something like the joy of a religious hope in a happier future. But, however that may be, Prof. Cairnes brings to the discussion of the subject his prejudices as a politician, or an Englishman, or some other perversity, and, as we are now to see, they blind him to the truth of the subject he has taken up.

Prof. Cairnes, as we have said, either does not understand Spencer, or he culpably misrepresents him. Everybody knows, or, at least, every one who writes upon the subject *ought* to know, that Mr. Spencer's labors for the last fifteen years have been only preparatory to the elucidation of the principles of sociology. He has but just entered upon that work which will occupy him, if he lives, for the next five or six years. The doctrine of social evolution he has not yet developed; and by that alone can he be fairly judged as a sociologist. Prof. Cairnes condemns him before he begins. His article is a review of the "Study of Sociology" which he assumes to embody "the elementary doctrines of the new science." But that work attempts no such thing; it, in fact, carefully avoids the consideration of the principles or science of the subject. It discusses outlying questions, which have, indeed, a bearing upon the general subject, but it is neither an exposition nor a defense of its elementary doctrines.

But, although Mr. Spencer's views upon sociology have hitherto only been put forth partially and incidentally, there is no excuse for such erroneous conceptions of them as Prof. Cairnes entertains. He goes back to an old essay on the "Social Organism," in which Mr. Spencer, nearly twenty years ago, pointed out some analogies between the structure and actions of the body politic and those of individual organisms, and says that Spencer's doctrine of social evolution is based upon this analogy. He asserts that Spencer's theory of social evolution "represents a speculation transferred from the domain of physiology and zoology into that of social inquiry, and the speculation so transferred is applied without question or scruple to the interpretation of human affairs;" and, again, he speaks of "that analogy between the social and animal organisms on which the whole speculation is built up." We cannot conceive a grosser misapprehension than this. Mr. Spencer maintains that the law of evolution is universal because the evidence of it is found in each of the great divisions

of natural phenomena. In the social sphere the principle rests upon observed effects, and is an induction from the facts belonging to that sphere, just as strictly as the law of organic evolution is derived from facts in the biological field. This is abundantly shown in "First Principles," where the law, as applied to society, rests upon its own independent basis, and not upon the analogy of the social to the individual organism. So far, indeed, from proceeding by the method stated by Prof. Cairnes, Mr. Spencer actually proceeded by the reverse method: instead of beginning with biology and carrying out his conclusions to be applied to society, he began first, and early in life, the direct study of social phenomena, and pursued that line of inquiry many years before taking up biology. With Prof. Cairnes's criticism of the "analogy" we have nothing to do; nor is it of any importance that Huxley and Spencer had a controversy about it. The question is as old as Plato, and both Cairnes and Huxley admit that the analogy has some value—Mr. Spencer never claimed for it any thing more. We only say that the use the reviewer makes of it proves that he has taken but little pains to inform himself of Mr. Spencer's real doctrines.

Let us now consider Prof. Cairnes's main ground of attack upon Spencer's theory of social evolution. Calling attention to the fact that the social condition of the largest portion of the human race is stationary, and that there are numerous examples of social retrogression, he charges Mr. Spencer with ignoring these facts because they have no place in his theory of evolution. We have now, he says, three thousand years of history, and "surely, before propounding his speculation as a law of human society, from which he is at once justified in deducing consequences of the largest kind bearing upon human conduct, Mr. Spencer was bound to consider what amount of countenance or support it received from the evidence derivable from such fields of research; *but from the application of this test he has wholly abstained*" (the italics are ours). And, after referring to the backward movement of human affairs in Europe, for many centuries, he adds that "the verdict of history, as now understood by its most competent interpreters, is distinctly opposed to the theory of social evolution enunciated by Mr. Spencer. *Now, this is a fact that has been completely ignored by that distinguished writer:* he has simply passed it by as not concerning his argument; and, in doing so, has, as I contend, set at naught one of the best-understood canons of the inductive method." These passages, and the whole argument in which their thought is expanded, simply show (if we may be allowed to speak plainly) that Prof. Cairnes does not know what he is talking about. His statements are squarely against all the facts. So far is it from being true that Mr. Spencer ignores history in his social theories, that he has made the most elaborate and extensive preparations in this direction for future use in working out the principles of sociology. Nor were these preparations mere projects yet to be executed. The facts of the sociological history of England, on a most comprehensive plan, had been collated, and organized, and published a year and a half, when Prof. Cairnes comes forward to charge him with neglecting history. The professor, indeed, seems not to have the faintest idea of Mr. Spencer's real attitude toward his subject. Had he examined the work just referred to, which was his bounden duty as a reviewer, he would have discovered that, so far from ignoring history in social affairs, Mr. Spencer is doing more than any other man to bring it forward and give it its true place in the scientific study of society. He would have found that, of the three great social groups into which the human race is divided by Mr. Spen-

cer, one is classified as low and stationary, and another as decaying or retrograding; and that the social career of the declining and dead civilizations, Jewish, Egyptian, Greek, Roman, Mexican, and Peruvian, are made the subjects of investigation, as well as the advancing communities of the present time. Prof. Cairnes declares that Mr. Spencer has "completely ignored" the phenomena of social retrogression, when within a year Mr. Spencer has issued the first volume ever printed on the sociological history of a group of decayed communities.

Nor is this all; there is even less excuse than now appears for the absurd misrepresentations in Prof. Cairnes's article. Mr. Spencer has commenced the "Principles of Sociology," and two numbers of that work had appeared before Prof. Cairnes published his criticism. Again we say, that he was bound to have consulted these, or have held his peace in regard to Mr. Spencer's doctrines. The following quotation from the part last issued, and which was printed two months before the *Fortnightly* article, will settle the question, and render any further notice of the professor's argument unnecessary:

"Evolution is commonly conceived to imply in every thing an *intrinsic* tendency to become something higher, but this is an erroneous conception of it. In all cases it is determined by the coöperation of inner and outer factors. . . . Usually neither advance nor recession results, and often, certain previously-acquired structures being rendered superfluous, there results a simpler form. Only now and then does the environing change initiate in the organism a new complication, and so produce a somewhat higher type. Hence the truth that while for immeasurable periods some types have neither advanced nor receded, and while in other types there has been further evolution, there are many types in which retrogression has happened. . . . Of all existing species of animals, if we include parasites, the greater number have retrograded from a structure to which their remote ancestors had once advanced. Often, indeed, progression in some types *involves* retrogression in others. For always the more evolved type, conquering by the aid of its acquired superiority, tends to drive competing types into inferior habitats, and less profitable modes of life; usually implying some disuse and decay of their higher powers.

"As with organic evolution, so with super-organic evolution. Though, taking the entire assemblage of societies, evolution may be held inevitable as an ultimate effect of the coöperating factors, intrinsic and extrinsic, acting on them all through indefinite periods of time, yet it cannot be held inevitable in each particular society, or even probable. A social organism, like an individual organism, undergoes modifications until it comes into equilibrium with environing conditions, and thereupon continues without further change of structure. When the conditions are changed, meteorologically or geologically, or by alterations in the Flora and Fauna, or by migration consequent on pressure of population, or by flight before usurping races, some change of social structure is entailed. But this change does not necessarily imply advance. Often it is toward neither a higher nor a lower structure. Where the habitat entails modes of life that are inferior, some degradation results. Only occasionally is the new combination of factors such as to cause a change constituting a step in social evolution, and initiating a social type which spreads and supplants inferior social types. For with these super-organic aggregates, as with the organic aggregates, progression in some produces retrogression in others; the more-evolved societies drive the less-evolved societies into unfavorable habitats, and so entail on them decrease of size, or decay of structure.

"Direct evidence forces this conclusion upon us. Lapse from higher civilization to lower civilization, made familiar during school-days, is further exemplified as our knowledge widens. Egyptians, Babylonians, Assyrians, Phœnicians, Persians, Jews, Greeks, Romans—it needs but to name these to be reminded that many large and highly-evolved societies have either disappeared, or have dwindled to barbarous hordes, or have been long passing through slow decay. Ruins show us that in Java there existed, in the past, a more developed society than exists now; and the like is shown by ruins in Cambodia. Peru and Mexico were once the seats of societies large and elaborately organized, that have been disorganized by conquest; and where the cities of Central America once contained great populations,

carrying on various industries and arts, there are now but scattered tribes of savages. Unquestionably causes like those which produced these retrogressions, have been at work during the whole period of human existence. Always there have been cosmical and terrestrial changes going on, which, bettering some habitats, have made others worse; always there have been over-populations, spreadings of tribes, and escape of the defeated into localities unfit for such advanced social life as they had reached; always, where evolution has been uninterfered with externally, there have been those decays and dissolutions which complete the cycles of social changes. That supplanting of race by race, and thrusting into corners such inferior races as are not exterminated, which are now going on so actively, and which have been going on from the earliest recorded times, must have been ever going on. And the implication is that remnants of inferior races, taking refuge in inclement, barren, or otherwise unfit regions, have retrograded."

MENTAL PICTURING IN SCIENCE.

We pointed out some indications last month of the mitigated asperities in the Tyndall controversy, as evinced by the tone of the graver periodicals, and may now observe that a much more conciliatory and reasonable spirit begins to be manifested by the newspaper press. The topic is by no means worn out, and if our theological friends have the interests of education at heart, and are at all capable of gratitude, they will vote a medal of honor to Prof. Tyndall for his eminent services in arousing multitudes to think carefully upon important questions of which they have hitherto thought carelessly or not at all. There has not, in a long time, been such a general scientific and philosophic shaking-up as the Belfast Address has produced; and the result must be, that many will work their way to much clearer conceptions of the scope of science and its relations to religion.

A leading article appeared in the last issue of *Church and State*, in the most excellent temper, but still ingeniously protesting against some of Prof. Tyndall's views. In his late reply to his critics, the professor has said: "The kingdom of science, then, cometh not by observation and experiment alone, but is completed by fixing the roots of observation and experiment in a region inaccessible to both, and in dealing with which we are forced to fall back upon the picturing power of the mind." To this the writer takes exception, and questions whether it is right or advisable for the scientist "to fall back on the picturing power of the mind." He thinks it is allowable for the theologian to do this, but to scientists he says: "Why not go on observing, and leave others to conjecturing?" And, again, he remarks: "Of one thing we are sure, that, so far as the scientific investigators fall back upon the picturing power of the mind, they must relinquish the claims of *positive* science."

This strikes us as a quite erroneous view of the case. The scientific investigator can no more renounce the picturing faculty in his mind, than he can renounce the heart in his body; and he can no more confine himself to observing and leave conjecturing to others, than he can confine himself to digestion and leave respiration to others. To suppress the picturing power of the mind would put an embargo on all intellectual operations, and, in fact, put an end to thought itself. For what is thought but representation in consciousness, and what is it to represent but to reproduce mentally, to picture, to image, or exercise the image-forming faculty—the imagination? There are, of course, other mental operations, but they are performed upon the representations in consciousness—upon the objects of thought imagined, or imaged to the mind's eye. Not a step can be taken in science except by this mental procedure. The object of science is truth, and what is truth but the faithful representation in thought of the order and relations of natural things? Everybody imagines, but their mental images do not always

correspond to the realities; their mental pictures *mis*represent. The man of science imagines—frames a view as the initial step of all his procedures; and then, by the mental processes of comparison, reasoning, inference, proof—guided by observation and experiment—he strives to give truth to his view; that is, to harmonize it with facts, and all its parts with each other. Our writer says that science starts with observation and experiment, but the real starting-point is farther back. A mental representation must be made before it can be verified. A certain state of things is conceived or put together in thought, and is called an hypothesis; and then observation and experiment are appealed to, to test the correctness of the representation—the truthfulness of the mental picture. Science is not merely seeing with the eye or fumbling with instruments—any blockhead can do these—but it is to reconstruct Nature in thought, representing all her diverse objects, subtile relations, and complexities of change, so truly, that by every test the representation shall answer to the verities. To do this, the imagination or image-forming faculty comes into incessant play. And more than this, the genius of the discoverer depends, first of all, upon the vividness of his imagination and the power of keeping his pictures steadily before the mind's eye until their errors are detected or their accuracy established. The work of science, in fact, consists, from first to last, in the *verification of mental pictures*. The scientific man must be fertile in imaginative resources, but stern in his rejection of views that cannot be adjusted to facts. The poet has no such discipline, for his object is not truth. The theologian has no such discipline, for he cannot submit his views to observation and experiment, so as to test their congruity with the objective world and with each other. The picturing faculty is employed by all minds, but only the trained scientist makes it subservient to the true understanding of the order of things around.

Sufficient has been said to show that imagination is indispensable to science; but it may be asked, "If observation and experiment are the means of science for controlling the imagination, and if they furnish the conditions of its valid exercise, why prolong the vision beyond the line of experimental evidence?" The reply is, that senses and instruments are imperfect, and their indications require to be supplemented by reason. They break down at a certain point, but that point is very far from being the limit of Nature. As experiments are perfected, the line of sensible demonstration is pushed backward constantly, disclosing a continuous order. It is a right of reason and a legitimate procedure of science, to pursue this order, if the explication of known phenomena require it. The results, of course, must conform to what is established—must harmonize with all that observation and experiment have gained; but thought may be compelled to go far deeper than experiment for the explanation of facts already known.

To make this statement more concrete, let us take the very case put by Prof. Tyndall—the ultimate constitution of matter. By various lines of proof, the physicist is brought to the conclusion that there are such things as amazingly-minute physical units which he calls molecules. In their smallness they are far beyond the border of all sensible observation; but he is driven to the conclusion that they exist as realities, and he has to represent them in thought. He mentally pictures a molecule as the smallest particle of matter that can exist separately and retain its physical properties. Prof. Thompson finds physical and mathematical evidence pointing down to the actual size of molecules. From this he infers that those of water have diameters that fall within the limits of $\frac{1}{2500000000}$ and $\frac{1}{5000000000}$ of an inch; and adds that, if

we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket-balls. The evidence in this case may be insufficient; it may become more complete; but the conception of physical units, in subsensible depths far beyond the reach of possible observation or experiment, is inevitable to the physicist and perfectly legitimate to science.

The chemist now steps in with a new view of the case. He accepts the molecule of the physicist, but to him it is no longer a unit. He decomposes it into new kinds of matter, with new properties. He resolves it into a still lower order of units, which he terms atoms. Chemistry presents us with a vast mass of observations and experiments, but they cannot be connected, resolved, interpreted, and stated, except in transsensible terms of the imagination—molecules and atoms. Physics and chemistry, in their latest and highest aspects, are compelled to fall back upon these conceptions of subsensible units as nothing less than the ultimate foundations of science.

THE INTERCOLLEGIATE SPOUTING-MATCH.

"The higher education" advances apace. We chronicled in due time the great impulse that it received at Saratoga last summer, when a mob that no man could number hustled its dusty way over to the lake to see which set of collegians could pull through the water the fastest. One of the boats came out ahead—as was rather unavoidable—whereupon everybody shook hands and uproariously agreed that this college business must be in a very prosperous way.

And now the "higher education" has taken another spirited stride forward. Half a dozen colleges in different parts of the country having made up a grand spouting-match, hired the Academy of Music in the metropolis for the exhibition, got together three newspaper editors for judges, brought on their most promising young declaimers, and let off the show before a large and admiring audience. Nothing was wanting to call out the best efforts of the candidates, who were fired by personal ambition, collegiate rivalry, auditorial applause, and impending newspaper glory, while even more peppery and pungent incentives were by no means overlooked. It is related that, on a certain occasion, the sportsmen somewhere out West resolved to have a grand fox-hunt in the true old English style. And so they came together with horses and hounds, not forgetting to bring the indispensable little beast they were going to hunt, which came secure in its cage. When all was ready, they let the fox go. The animal might probably have been trusted to run by natural instinct, but, to furnish him with an immediate motive for making his best speed, they gave him a cut with a horse-whip as he escaped. In the case of the young orators the starting-fillip was different. The high incentives might perhaps have sufficed to unseal the fountains of eloquence, but, to insure a gushing flow, an additional stimulus of $175 was held out as a premium to the winner. Whether the greenbacks were put in a purse and placed in conspicuous view of the contestants, does not appear. Be this as it may, they strove with each other, the editorial discrimination was invoked, some one got the money, and the others of course didn't; and it was agreed all around that the cause of the higher education had been moved along several notches.

Well, if the potsherds of the earth may be permitted to strive with each other, why not the colleges?—if the boys

of the street may pitch pennies for the sake of winning them, why should not the students secure a little pelf by a trial of skill with their tongues? — all we ask is that the policy shall be formulated and recognized. We hope that in future the advocates of the perfection of our college system of culture will consent to regard it as a composite system working in various ways, and appealing to divers motives for the attainment of its ends. Hitherto we have been assured with great emphasis that this system—the perfected and purified result of centuries of experience—has risen above all low and sordid inducements, and rests its superior claims on the dignity of scholarship, the value of knowledge for its own sake, and the intrinsic excellence of culture. When it has been urged that college studies are susceptible of wise amendment, and should be arranged with some reference to the future needs of the student's life, the suggestion has been repelled with indignation, as born of a base, utilitarian, bread-and-butter motive that would degrade the lofty and disinterested ideal that should ever be held before the student—the cultivation and discipline of his intellectual powers, as an end in itself, to be debased by none of the vulgar incentives which animate the beastly crowd in the practical scrambles of life. To be sure, we have known that, notwithstanding all this sounding talk, the higher institutions have not hesitated to use the vulgar spurs of action by which human nature is everywhere moved. They are very far from having disdained the appeal to mercenary motives. The great universities of England are notoriously worked by cash-bribes, in the shape of fellowships—honorary positions with incomes attached, which are securable by proficiency in certain prescribed studies. The universities have immense incomes and are enabled to cling to their mediæval courses of study in defiance of public opinion and the demand for reform, mainly through the pecuniary prizes which in this way they hold out to students. And this policy, in modified forms, is extending to other collegiate institutions as fast as they can get the money for the purpose. Rich people are inspired with the ambition of encouraging learning; that is, they get some crotchet or hobby of education, which they are willing to back with money, and then prizes are founded, and the students set into a fever of emulation to gain them. In this way sordid inducements become a part of the system, and, as most of the donors have been educated in the old way, their money goes to perpetuate it. But no sooner do the friends of science demand that modern studies shall have an equal chance with the ancient studies, and that the knowledge which is necessary for guidance in life shall be put upon an equality with dead languages, than the champions of the colleges are at once upon their dignity, and beg to know if the grand old liberal and ennobling culture consecrated by centuries is to go down before the narrow and selfish exactions of a materialistic and money-getting age. But these gentlemen are not, after all, unmindful of the educational potency of filthy lucre, nor that students may be plied with the motives of the gamester—the passion to win. The intercollegiate speaking-match had about it more of the ethics and incitements of the cockpit than is quite consistent with the lofty claims that are put forth in regard to the inspirations of the higher culture. We doubt if the multiplication of intercollegiate contests and ostentatious rivalries, whether for the winning of purses, or the beating of antagonists, or the exhibition of accomplishments, is either healthy in its influence upon the internal life of the institutions themselves, or favorable to that quiet, concentrated, uninterrupted mental exercise which is the indispensable condition of solid attainments and sterling scholarly character.

LITERARY NOTICES.

REPORT OF THE CHICAGO RELIEF AND AID SOCIETY OF DISBURSEMENT OF CONTRIBUTIONS FOR THE SUFFERERS BY THE CHICAGO FIRE. Printed for the Chicago Relief and Aid Society, at the Riverside Press, 1874.

THIS volume is one of unique and remarkable interest, founded on one of the most terrible tragedies in all history. Within a period of twenty-four hours an immense portion of a great city was laid in ashes. The total area burned over was 2,124 acres, or nearly 3¼ square miles, containing about 73 miles of streets and 18,000 buildings, while, of a population of 334,000, the houses of 100,000 were destroyed. Of the experience of that terrible Sunday night, when the conflagration spread through the city before a driving gale of wind, the "Report" remarks as follows:

"As the fire raged, the number of homeless people became greater and greater, and, possessed by fright, many were inapt in expedients of self-preservation. Many sought temporary abodes for themselves and their effects in the hospitable homes of their neighbors. But the hope of security here was soon surrendered, and those who had been but mere spectators of their neighbors' calamities, were now panic-stricken householders, engaged in taking care of themselves, their families, and their property, until thousands together were fleeing west, north, and south, in consternation, and frequently in despair of saving life. And thus the streets were filled with an indescribable mass of fugitives forcing their way through the stifling clouds of dust, smoke, and cinders, and the confusion and utter chaos of the night—a night lurid with flames, the reflection of which, in itself, gave to the countenances of these fleeing thousands an awe-stricken and almost unearthly aspect. The hissing and crackling of the flames, and the deafening roar of the gale, the pelting cinders and brands, and the crumbling of material, gave tragic coloring to the scene, and leave the night memorable in the minds of those who witnessed it, as a picture of appalling horror, distinct in its outlines, weird in its dark shadings, but utterly incapable of verbal representation."

But, appalling as was this phase of the great disaster, the consequences it immediately entailed were hardly less dreadful:

"Comparatively few, of those who had fled before the flames, had tasted food since early Sunday evening, and hunger came to them to add its terrors to those of exposure and, in many instances, apprehension of death. And then came the greatest terror of all—the consciousness of the fact that families had been separated; husbands and wives, parents and children, were missing. The flight had been so rapid, and, in all directions, the thoroughfares had been so obstructed, and in some cases utterly impassable, by the crowding of vehicles and masses of people, and the city itself a wave of fire, it is no marvel that, under these circumstances, thousands, for the time, were lost sight of, and became lonely wanderers; and that hundreds perished in the flames. The seeds of permanent or temporary disease sown, the bodily suffering and mental anguish endured can never have statistical computation or adequate description."

Instant measures were required to meet the emergency. The news of the calamity spread by telegraph through the world, roused universal sympathy, and back, along the wires, as if by reflex action, came prompt offers of abundant assistance. The telegraph poured in reports of world-wide contributions in money, and the railway-trains came freighted with provisions, clothing, merchandise, and all the necessary supplies which a suddenly unhoused and bankrupted community might require. To meet these universal proffers of help, and carry out the work of distribution, the "Relief and Aid Society" was called suddenly into existence, and the present "Report" is the history of its experience. Its officers consisted of the ablest men in Chicago, and the record of their prompt and vigorous doings is in the highest degree interesting and instructive. The report they have issued is a model of systematic, detailed, and comprehensive statement of operations, and will be permanently valuable, both as an impressive chapter in the history of Chicago, and as a register of experiences that will be valuable for consultation in similar emergencies that are liable to happen in other cities. The volume before us is gotten up in superior style, but we hope there is a cheaper edition for general circulation.

THE DOCTRINE OF DESCENT, AND DARWINISM. By OSCAR SCHMIDT, Professor in the University of Strasbourg. With Illustrations. 334 pages. Price, $1.50. D. Appleton & Co. No. XIII. of the "International Scientific Series."

A POPULAR exposition of the general doctrine of Development and Descent, within moderate limits, has been long wanted. Mr. Darwin's works are voluminous, and they elaborate special points with a minuteness of detail and a wealth of learning that are the delight of the student, but are not attractive to the general reader. A compend of the main facts and essential logic of his system, as now widely accepted by naturalists, is therefore a desideratum in scientific literature. Various attempts have been made to meet this need, but they have generally been defective in statement, and made by men who did not know the subject at first hand. Prof. Schmidt's volume fairly covers the ground, and is brought within convenient limits for the general reader; while its author is an independent investigator in natural history, and has made his own original contributions to the theory which his book explains. As a piece of exposition the volume is quite remarkable, and its writer may be congratulated for having done his part toward relieving German men of science from the imputation recently intimated by Helmholtz, that they are behind those of other countries as lucid and successful popular teachers. There are a meatiness and a density of thought in this little work which betray the close German thinker, and keep the reader well occupied; but there are a wit, point, and polemical force in his pages, that relieve them from dryness, and well sustain the reader's attention. Yet the characteristic of the volume is that the author has seized the essential points of the great argument, and brought out, with unexampled success, the strength of what may be called the Darwinian position. The broad philosophic doctrine of Evolution he does not attempt to discuss, but limits his argument to the field of biology, to the Animal World in its Present State, the Phenomena of Reproduction, Historical and Paleontological Development, the Geological and Geographical Distribution of Life, Heredity, Reversion, Selection, Derivation, and Pedigree. An able chapter is given to Special Creation and the Nature of Species; the Bearing of Linguistic Inquiry upon the Doctrine of Development is presented; and the concluding chapter is devoted to the question of the Descent of Man. On all these subjects the author is up to the latest results, and presents them in a well-methodized form.

This volume covers very important ground in the popular scientific series to which it belongs, as its doctrines are sometimes implied and frequently referred to in the other books, and it is therefore satisfactory to know that Prof. Schmidt has executed his work with judgment and ability.

RELIGION AS AFFECTED BY MODERN MATERIALISM. By JAMES MARTINEAU, D. D., LL. D. With an Introduction by the Rev. H. W. BELLOWS. 68 pp. Price, 75 cents.

DR. MARTINEAU is one of the most affluent and captivating of modern theological writers, and is regarded as perhaps the leading English champion of Unitarian heterodoxy. His "Essays, Philosophical and Theological," reprinted by the Putnams, range over a wide variety of topics, and display much acuteness and logical force, but their chief characteristic is the imaginative raciness of their style. The essay now issued, and which was delivered as an address before the Manchester New College, is a brilliant rhetorical polemic, called forth by Tyndall's address, in which the author aims to expose what he regards as the inconsistency, the baselessness, and the absurdity, of modern materialistic philosophy. Many of his hits are fine, and many of his sarcasms biting, and the whole discussion is most readable, but we think the author leaves the subject very much as he found it. We fail to see that his breadth and liberality give him any advantage in *this* discussion over the narrow and bigoted theologian. As an historical fact, theological doctrines have stood in the way of Science at every great step of its advancement. Nor have the theologians ever consented to take their doctrines out of the way; the disagreeable duty has been imposed upon Science, all along, of displacing them. Nor does there seem to be yet, on the part of theologians, much disposition to change their tactics; they still plant down their dogmas in

the pathway of investigation, and then denounce the antagonism of science, and the aggressiveness of its cultivators—because they will hold to their old course and drive on. In the present phase of the conflict, it is insisted upon, with a strange perversity, that Science is somehow the rival of the Deity; that what Science gains, the Creator loses. To the vulgar religious mind, thunder and lightning were formerly regarded as the immediate displays of Divine power and intervention in the management of earthly affairs, and, when Science affirmed that it could discern the promise and potency of these effects in matter, the ignorant theologian protested that God was in this way expelled from so much of his universe. Science has thus been interpreted as driving him out of sphere after sphere, until at last only a corner of the universe remains where the operations of the Divinity can be seen, and that is the realm of life. Prof. Tyndall now comes forward and says that he sees also in matter the promise and potency of every form of life, and the cry is raised that this is the final audacious aggression of Science, which drives the Divinity from the universe, and lands the human mind in scientific materialism and scientific atheism. If we understand Dr. Martineau, he holds this position in common with the narrowest of the orthodox. Yet there are many divines who see that the whole course of theology in this respect has been wrong, and that, rightly viewed, every successive step taken by Science, in conquering the world to the laws of order, has only strengthened and exalted the true view of the Divine government of the world.

THREE ESSAYS ON RELIGION. By JOHN STUART MILL. 302 pp. Price, $2.50. New York: Henry Holt & Co.

THE three elaborate essays which constitute this work are on the following subjects: I. Nature; II. Utility of Religion; III. Theism. The first two of these were written some twenty years ago, the last within half a dozen years; but Miss Taylor, the editor, in her "Introductory Notice," says that Mr. Mill intended to publish the essay on Nature—one of the first written—in 1873. From this it would appear that the views upon religious subjects which Mr. Mill entertained a quarter of a century ago were those that he continued to hold during life; indeed, Miss Taylor says that "it is certain that the author considered the opinions expressed in these different essays as fundamentally consistent;" and she adds, "It is apparent that his manner of thinking had undergone no substantial change."

Now, whatever Mr. Mill wrote upon subjects that had engaged his long and earnest attention was always valuable and worthy of thoughtful perusal; and, certainly, his reflections upon so universally important a matter as religion are entitled to grave consideration. And yet Mr. Mill's claim to be heard rests only upon the broad presumptive ground of his acknowledged greatness as a thinker, and our interest to know what he said is much the same as it would be in the views of Plato, Averroes, or Kant. For, as a thinker, Mr. Mill is already historic—historic not merely in the sense that he is dead, but that he is separated from the present by a great epoch of change in the philosophic view of Nature, and as belonging to an old dispensation of thought. As we have shown before, Mr. Mill virtually antedated the scientific era. He was educated in the most despotic manner, and with no more reference to science than if that agency had not appeared in human affairs. His whole discipline and mental furniture, although thorough and full, were on a method that had been perfected before science arose; and it was natural, if not inevitable, that his philosophic opinions on the subject of Nature and religion should have been in substantial harmony with the old skeptical school. Many questions are undoubtedly handled with originality and power; but the standing-point from which the whole subject is considered belongs to the last century.

That this stand-point has been greatly altered within a few years, so as to give new aspects to old religious problems, can hardly be doubted. The doctrine of evolution, which has latterly come forward so prominently, is not merely a theory of the origin of animal diversities; it is nothing less than a philosophy of Nature, and gives a new complexion to the great religious questions in which the interpretation of Nature is involved. Our space will not allow

us to go into this inquiry, but the case was so well stated, the other day, in relation to Mr. Mill, in the editorial columns of the *New York Times*, that we cannot do better than to quote a passage or two from the article. The writer says:

"Much as Mr. Mill had labored in the field of modern metaphysics, he was by no means so familiar with the modes of reasoning of modern science. Had he been more so, he could never have indulged in his irreverent and almost flippant objections to the perfection and the ends of the workings of Nature. Nor would he have been so confident of the tendencies in Nature toward pain and degeneracy. The truth is, to the modern natural philosopher Nature is by no means so simple a machinery, or collection of guided forces, as it was to the investigator even twenty years since. Darwinism has changed all that. The simplest results in natural phenomena are plainly the effects and balancings of countless forces and forms of life, perhaps through millions of ages. The aspect and features, for instance, of a summer field—its flowers, insects, shrubbery, and animals, the soil and rocks and contour, the very hue of the flowers and the color of the insects—every simple phenomenon in it is the result and final balance of struggling forms of life and opposing forces, which must have been working under a guiding hand to produce this effect for '*sons of sons*.' The philosopher who should say that this did not show contrivance, or the perfection he expected, or that this complicated machinery suffered from jars, friction, and defects, would now, in the judgment of the most skeptical scientific men, be like a savage criticising the machinery of a steam-engine or the operations of a Babbage counting-machine. The matter is too complicated for any human observer to form any intelligent opinion upon. He neither sees the beginning nor the end. He is not certain that he can trace out a few threads of the intertwined web, even for a short distance. His best theory, that of 'the survival of the fittest,' is only a negative theory. It shows why forms of life are destroyed, but never 'the origin of species.' The only thing which a philosophical observer can do with any reason is to observe, during the short space of human history, *the drift of things*. Now, modern science, whether it be correctly based or not, is singularly opposed to Mr. Mill's pessimism in this.

"According to Darwinism, at least (which Mr. Mill certainly would recognize as a good working hypothesis), there is nothing in the universe existing or created for pain alone. Every instrument of destruction or torture—the claws of the tiger, the sting of the hornet, the venom of the rattlesnake, the teeth of the shark, the beak of the hawk—are not designed, or have not arisen, to give pain without purpose. They are all originally means of defense, or means of gaining sustenance, or weapons of attack in the struggle for food, or variations of harmless organs. Pain is incidental to them. And pain, in the Darwinian theory, is never an object *per se*, except as it tends to improve the subject. We are not now defending this theory of the universe; we only urge that modern science, on which Mr. Mill so confidently rests, does not present us with a universe where pain is the apparent object of creation, or where it has no useful ends.

"Moreover, Mr. Mill would be surprised to find that under the Darwinian hypothesis there is no degeneracy of the world, no drift toward the worst. Nature, to the Darwinian, is by no means so black as the elder and younger Mills paint her. According to the development hypothesis, there is an eternal progressive movement through the whole universe toward higher forms of life; in other words, modern science believes in necessary and ever-continuing advance. But a current toward the Best, a plan of the Cosmos which points toward perfection, a drift in the direction of what is complete, a movement like that of the stars of heaven, continuing slowly but surely through countless millions of ages, toward one centre of the universe—the perfectly Good—is surely one of the grandest of all indications in natural theology of a benevolent and perfect Creator. And for an observer, who has but a moment's time for observation, to criticise the movement because it is slow, reaches the height of irreverence and conceit."

THE ELEMENTS OF THE PSYCHOLOGY OF COGNITION. By ROBERT JARDINE, B. D., D. E. Sc. Macmillan & Co. 289 pp. Price, $2.

THIS volume has nothing marked about it that calls for attention. It belongs to a class, already numerous, which purport to be introductions to the study of the human mind. It is metaphysical in its method, and old in its inculcations. While the author designs it "principally for the use of students" who are beginning their philosophical studies, he confesses to another purpose, as follows: "The writer is ready

to admit that one principal object which he kept before his mind in the preparation of the book, was to show the inadequacy and unsatisfactoriness of a prevailing system of psychology which may be indicated by the word phenomenalism." By phenomenalism we suppose he means corporealism, or the psychology which takes organic conditions into account in studying mental effects. But he "shows the inadequacy" of that method chiefly by ignoring it, and if disembodied spirits want a text-book of psychology adapted to their circumstances, the present work may be recommended to them as so well suited that it would not need revision to free it of any sublunary dross.

THE INFLUENCE OF MUSIC ON HEALTH AND LIFE. By Dr. H. CHOMET. Translated from the French by MRS. LAURA A. FLINT. 242 pp. Price, $1.25. G. P. Putnam's Sons.

AN elegantly-printed little volume, with an attractive title, which is suggestive of a most interesting class of scientific questions. But the contents of the book are sorely disappointing. The questions we expected to meet are not considered, and the little science there is is bad. In a chapter devoted to "The Nature and Origin of Sound," the current physical explanation of the phenomena is rejected, and a sonorous or musical fluid is resorted to. The author says: "Why do not all the extended cords of a musical instrument, such as a piano, violin, violoncello or guitar, repeat together the tone or cry of the voice which utters sounds above them? Why, of all the cords of the same instrument, do those only which are in unison with this voice produce sound? Did not the noise, the sound, the sonorous wave, as they choose to call it, which escapes from the mouth, strike, disturb, and agitate all the strings? Yes, but the sonorous fluid did not find all of these its *Leyden jar*, nor in any the capacity for being charged with the sonorous fluid. This, I think, is the explanation of the phenomenon that can never be explained by the theory of the molecular vibration of the bodies, or of the undulations of the air." Where such crude notions are entertained, we cannot expect a very refined analysis of the relations of music to the nervous system; nevertheless, the volume contains a good deal of information in which the lovers of music may be interested.

TABLES FOR THE DETERMINATION OF MINERALS BY THOSE PHYSICAL PROPERTIES ASCERTAINABLE BY THE AID OF SUCH SIMPLE INSTRUMENTS AS EVERY STUDENT IN THE FIELD SHOULD HAVE WITH HIM. Translated from the German of Weisbach. Enlarged and furnished with a Set of Mineral Formulas, a Column of Specific Gravities, and one of the Characteristic Blow-pipe Reactions. By PERSIFOR FRAZER, Jr., A. M., Assistant Geologist of the Second Geological Survey of Pennsylvania, lately Professor of Chemistry in the University of Pennsylvania. 117 pages. J. B. Lippincott & Co. Price, $2.00.

THIS is a very valuable little hand-book for the student of practical mineralogy, and an immense amount of careful and accurate information has been condensed into its pages. It grew out of the necessities of practical teaching in the school of Freiberg, and has been revised and adapted for use in this country by an experienced American geologist, and it is a guide to practical work which every student of minerals will find indispensable. The method of study to which it is tributary is thus indicated in a passage from the translator's introduction:

"Every one who has had the good fortune to study at the Royal Saxon Mining Academy, in Freiburg, will bear witness to the efficacy of the system there pursued for instructing young students in the art of distinguishing mineral species on the spot, by the aid of a tolerable memory, and an intelligent observation of a few of their most striking physical properties—both brought to the highest point of perfection of which they are capable by judicious cultivation, and kept in their best condition by assiduous daily exercise.

"The method of practical instruction pursued there, and which has been introduced by Freiberg graduates into many schools in this country, requires merely a cabinet of unlabeled minerals, and a professor who can determine—not one who has *learned* them. Each student, of a class of ten or more, places a tray of such minerals before him, and occupies the two hours devoted to "Praktische Uebung" in discovering, by the aid of the knife, the streak-tablet, the file, and the magnifying-glass,

the true nature of as many of these minerals as possible. There is, however, a large class of minerals (the silicates, etc.) which, unless distinctly crystallized, present considerable difficulties to the field-worker. To partly overcome these difficulties, the supplementary tables were added by Prof. Weisbach, whereby, through the instrumentality of a bottle of acid, a matrass, a blow-pipe, and a couple of fluxes, a still larger number of species can be identified."

POLARIZATION OF LIGHT. By WILLIAM SPOTTISWOODE, F. R. S., LL. D. 129 pp. Price, $1.00. "Nature Series." Macmillan & Co.

DR. SPOTTISWOODE is equally well known in the scientific and business world: in the scientific world as a mathematician, physicist, and member of the Royal Society; in the business world as printer to her Majesty, and the proprietor of an immense book-manufacturing establishment. The excellent little volume which is just produced on one of the most difficult departments of optics is, in a certain sense, the product of both the activities in which the author is engaged. It consists of lectures delivered at various times to audiences of the working people in his employ. In these lectures Mr. Spottiswoode attacked the most complex part of optical science, and one which it has hitherto proved most difficult to expound satisfactorily in a book; but, by the profuse employment of experiments, the lecturer was probably able to bring the subject within the range of his listeners' comprehension—its striking phenomena, at all events, if not their completest explanation. In this little volume the text is as clear as is consistent with extreme brevity, and the numerous well-executed woodcuts are valuable helps to the understanding of the subject, and will go far to replace the experiments which were made with the instruments represented.

OUTLINES OF PROXIMATE ORGANIC ANALYSIS. By ALBERT B. PRESCOTT, Professor of Organic and Applied Chemistry in the University of Michigan. 192 pages. New York: D. Van Nostrand. Price, $1.75.

THE science of chemistry is growing into immense proportions, and with its enormous expansion there comes a revolution in its theory of so radical a nature as to bewilder the old students, and raise a serious question how the prodigious mass of facts and details is ever going to be got into any thing like rational order. But, while Theory is perplexed, Practice proceeds with but little disturbance; only, as the field extends, division of labor has to be carried farther, and the more special departments of science are increasingly cultivated. The present work appears in obedience to this tendency, and furnishes a hand-book for a branch of analysis of no small importance, and which has hitherto hardly had its proper share of attention. The author remarks in his preface:

"Proximate organic analysis is not altogether impracticable, and organic chemistry is not solely a science of synthetical operations, even at present. It is true, as the chief analytical chemists have repeatedly pointed out, that in the rapid accumulation of organic compounds, the means of their identification and separation have been left in comparative neglect. It is true, also, that the field is limitless, but this is not a reason for doing nothing in it. Fifty years ago, the workers in inorganic analysis were unprovided with a comprehensive system, but they went on exploring the mineral kingdom, and using their scanty means to gain valuable results."

RESEARCHES IN ACOUSTICS. By ALFRED M. MAYER. Paper V.; from the *American Journal of Science and Arts.*

THOUGH but a pamphlet of 42 pages, it contains seven papers, each giving good, solid, original work on a difficult subject. Prof. Mayer has of late made acoustics a special field of investigation, and has given to science some admirable results.

METALLURGICAL PROPERTIES OF MISSOURI IRON-ORES, from the Geological Report of the State of Missouri, 1874. By ADOLF SCHMIDT, Ph. D.

THIS document is devoted to the metallurgy of iron. It specifies six ores in Missouri; gives their respective characteristics, and tabulates the quality of the iron when produced by smelting with charcoal, and coke, or coal, for the four irons technically known as foundery-iron, mill-iron, Bessemer-iron, and steel-iron. As a contribution to economical geology, it is valuable.

HALF-HOUR RECREATIONS IN NATURAL HISTORY. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

THIS is Part III. of Mr. Packard's series, "Half-Hours with Insects," which we have already mentioned in the MONTHLY. The author here considers the relations of insects to man. Of course those insects which live by preying on human kind receive special attention. We do not remember ever before to have heard that the *Cimex*, or bedbug, is originally a parasite of birds, especially doves and swallows. "The opinion," says Prof. Packard, "that the bedbug originally lived under the feathers of semi-domestic birds is strengthened by the fact that a European species of *Cimex* lives on the body of the swallow, another on the bat, while a third is found in pigeon-houses." Insects that are of service to man are also considered, and, singularly enough, we find in this category the cockroach, which, instead of being the unmitigated nuisance generally thought, is the mortal foe of the bedbug, and really does good work in ridding our houses of that disgusting pest. The pamphlet is full of useful information, and is well illustrated.

COMMUNITY OF DISEASE IN MAN AND OTHER ANIMALS. By W. LAUDER LINDSAY, M. D. Pp. 37.

THE author of this little essay was laughed at by eminent medical authorities in Edinburgh, when, some twenty years ago, he ventured publicly to affirm that certain human diseases may be artificially produced in the lower animals. Things have changed since then, and the identity of various diseases in man and animals is now admitted. Nor is this true of physical diseases only; Dr. Lindsay has found that the lower animals, or at least some of them, not only possess mind resembling that of man, but are subject to the same classes of mental disorder, produced by the same predisposing and exciting causes. The work before us gives a long catalogue of bodily and mental maladies that are known to be common to man and animals. The list includes typhus, yellow fever, puerperal fever, gout, hysteria, mania, idiocy, goitre, asthma, quinsy, and Bright's disease; and he shows that various poisons affect animals in the same way as they affect man.

METAMORPHISM PRODUCED BY THE BURNING OF LIGNITE-BEDS IN DAKOTA AND MONTANA. By J. A. ALLEN. Pp. 19.

THIS paper is reprinted from the "Proceedings of the Boston Society of Natural History," 1874. The *quasi*-volcanic metamorphisms of which it treats are singularly interesting, and here for the first time adequately described. In the "Bad Lands" of the Upper Missouri there exist highly-metamorphosed beds of clays and sands, accompanied by pumiceous and lava-like materials, which closely resemble volcanic products. Still the efficient cause was simply the burning of the underlying beds of lignite. Over hundreds and even thousands of square miles the evidences of these fires are to be seen in the mountain-ridges and buttes. There are frequent indications of the bursting through of these subterranean fires to the surface. Thus we find multitudes of jagged, chimney-like mounds of volcanic brescia. These were little volcanoes, having their seat of action in the burning coal-seam, ten, fifteen, or perhaps fifty feet below. The paper is one of rare value.

A RAMBLE ROUND THE WORLD. 1871. By M. Le Baron DE HÜBNER. Translated by Lady Herbert. New York: Macmillan & Co. 657 pages. Price, $2.50.

EXCURSIONS round the world are now made with such facility and regularity that the number of those who undertake them is rapidly increasing, while the variety and vivid contrast of the traveler's experiences, as he passes from continent to continent, offer an equal temptation to edify the stay-at-homes with a book describing the tour. A definite round-the-world literature of travel may thus be expected to grow up, and if it all proves to be as pleasant and instructive as Baron de Hübner's book, there will be no reason for regret. The present work is, however, more than an ordinary narrative of observation and traveling adventure. Its author, an Austrian nobleman, a man of culture and with wide experience of character, manners, and institutions, travels as a thinker, as well as a looker-on, and gives to his pages something of the insight of study as well as vivacity of narration. Of course it is impossible to go round the world

in eight months and see through every thing, and sum up the philosophy of governments, races, and civilization, within the limits of a single portable volume. Baron de Hübner does not attempt this, but he has the faculty of seizing the most important features of the subjects considered, and his reflections are always sensible and suggestive, and often acute and valuable. His work is divided into three parts: I. America; II. Japan; III. China. To the first part he devotes twelve chapters, and to Parts II. and III. each eight chapters.

The author tells us that the objects of his journey were "to behold, beyond the Rocky Mountains, in the virgin forests of the Sierra Nevada, civilization in its struggle with savage Nature; to behold, in the Empire of the Rising Sun, the efforts of certain remarkable men to launch their country abruptly in the path of progress; to behold, in the Celestial Empire, the silent, constant, and generally passive, but always obstinate, resistance which the spirit of the Chinese opposes to the moral, political, and commercial invasions of Europe."

THE VOICE IN SINGING. Pp. 192. THE VOICE IN SPEAKING. Pp. 164. Translated from the German of EMMA SEILER. Philadelphia: J. B. Lippincott & Co. Price, $1.50 each.

THE author of these volumes, a trained artist in vocal music, attempted to give instruction in that art, but found that the usual methods consist simply of empirical formulas, without any thing like scientific coördination. Accordingly, she undertook to discover for herself a rational method of instructing pupils. While Helmholtz was accumulating material for his great work, "Tonempfindungen," she became his pupil, and, to some extent, his collaborator. The result is these two volumes, which, in the words of Du Bois-Reymond, show an "acquaintance with all the facts and theories concerning the production of the human voice."

ON THE HABITS OF SOME AMERICAN SPECIES OF BIRDS. By THOMAS G. GENTRY. October, 1874.

THESE observations extend through four seasons, and are limited to Pennsylvania. The explanation why the cow-bird's egg hatches first in the nest of smaller eggs where it is clandestinely placed by the parent, is ingenious. The egg being larger than the others, is pressed upon by the incubating bird, hence it gets the most heat from the bird's breast. In descriptive ornithology science abounds, but, in recording the life-traits of birds, too little has been done, hence the peculiar value of this contribution.

NOMENCLATURE OF DISEASES, prepared for the Use of the Medical Officers of the United States Marine-Hospital Service. By the Supervising Surgeon, JOHN M. WOODWORTH, M. D. Washington: Government Printing-Office. Pp. 210.

THIS is a reprint of the "Nomenclature of Diseases" drawn up by a joint committee appointed by the Royal College of Physicians, London. Its republication is intended to aid in promoting the acceptance of a common nomenclature among the medical profession in all English-speaking countries.

THE FOES OF THE FARMERS: an Address delivered at Omaha, October 1, 1874, during the Nebraska State Fair, by Prof. A. L. PERRY.

THE foes herein discussed are "paper money, protective tariffs, and party spirit." Though approving the object of the Grange movement, the professor dislikes its secrecy. With a good deal in it that is somewhat *ad captandum*, such as "greenback-grasshoppers are worse than any other kind of grasshoppers," the address is an able tract on political economy as affecting the farmer's interest.

AN ELEMENTARY TREATISE ON STEAM. By JOHN PERRY, B. E. New York: Macmillan. Pp. 424. Price, $1.50.

THIS work is adapted to the use of students acquainted with algebra and familiar with at least the simple definitions of trigonometry and the elements of physics. It is published as one of a series of "School Class Books;" but who expects to receive theoretic or practical knowledge of steam at any "school" whatever? As a manual for the earnest student, who has access to steam-engines and steam-driven machinery, the work is valuable. It is divided into

four sections, whereof the first treats of heat, the second of steam-engines and boilers, the third of locomotives, and the fourth of marine-engines.

BULLETIN OF THE MINNESOTA ACADEMY OF NATURAL SCIENCES FOR 1874. Pp. 108. Price, 50 cents.

IT is gratifying to receive so substantial an evidence as this of the progress of science in the more recently-settled portions of our country. The titles of the papers in the present number are: "Birds of Minnesota," by Dr. P. L. Hatch; "Mammalia of Minnesota," by Dr. A. E. Ames; "Report of the Curator of the Museum;" "Prerequisites to a Proper Study of Science," by Dr. Charles Simpson; "Minnesota Geological Notes," by N. H. Winchell; "Antiquity of Man," by Dr. A. E. Johnson; "Astronomy—Scientific and Unscientific," by G. W. Tinsley.

ARCHIVES OF DERMATOLOGY: a Quarterly Journal of Skin and Venereal Diseases. Edited by L. Duncan Bulkley, M. D. New York: Putnams. $3.00 a year.

THIS is a new periodical, and as a "first number" the specimen before us is excellent. The *Archives* has no rival on this side of the Atlantic, and this circumstance, taken in connection with its intrinsic worth, ought to insure its success. Besides original communications, of which the present number contains six, the *Archives* will contain the Transactions of the New York Dermatological Society, clinical records, a digest of the current literature of dermatology, reviews and bibliography, and editorials.

THE PROTOPLASM THEORY. By EDWARD CURTIS, A. M., M. D. Pp. 23.

DR. CURTIS is Professor of Materia Medica and Therapeutics in the New York College of Physicians and Surgeons, and this is his introductory lecture for the winter course of 1873. It is an able argument for the oneness of the physical basis of life throughout the organic world. Though the lecture was originally addressed to medical students, it nevertheless may be read understandingly and with profit by the lay public.

ORGANIC CHEMISTRY. By W. MARSHALL WATTS, D. Sc., F. C. S. New York; Putnams. Pp. 130. Price, 75 cents.

THE primary aim of this little manual appears to be, to fit students for passing the examinations of the English "Science and Art Department." In so far as the book discusses its subject-matter proper, viz., the chemistry of the carbon compounds, it is as full and explicit as could be expected, considering its size.

REPORT UPON ORNITHOLOGICAL SPECIMENS COLLECTED IN THE YEARS 1871, 1872, AND 1873. Pp. 148.

CATALOGUE OF PLANTS COLLECTED IN THE YEARS 1871, 1872, AND 1873. Washington: Government Printing-Office. Pp. 62.

THESE valuable Reports form a part of the published work of the geographical and geological explorations under the charge of Lieutenant Wheeler. The Ornithological Report is by Dr. H. C. Yarrow, and has been revised and corrected by Robert Ridgway, of the Smithsonian Institution. The Catalogue of Plants is by Mr. Sereno Watson and Dr. J. T. Rothrock.

MISCELLANY.

The Cause of "Cold Snaps."—In a paper read before the American Academy of Science, Prof. Loomis offered a new theory to account for sudden falls of temperature, or "cold snaps," as they are called. The usual mode of accounting for these is by supposing that a current of cold air sets in from the north. A laborious investigation of the subject has led Prof. Loomis to the conclusion that these low temperatures, which occur at irregular intervals in every month, and particularly during the winter, are due mainly to the descent of cold air in the neighborhood, and that this descent of air results from the outward movement, which generally takes place from the centre of an area of high barometer. The theory is fully sustained by observations. As for the opposite theory, if the cold comes to us from the north, "whence does it come," asks Prof. Loomis, "to these colder known points on the earth's surface?" In summer, during a thunder-storm, the temperature often

falls 10° in a few minutes, but observations show that there was no air-current from the north. These sudden gusts of cold must descend from the higher atmospheric regions.

School Hygiene.—Dr. Richard Liebreich, the eminent oculist, read a paper on "School Hygiene" at a recent meeting of the London Social Science Association. He spoke of the influence of the posture of children during school-time, restricting himself to the discussion of two points, namely, short-sightedness and lateral curvature of the spine. Short-sightedness, he said, is produced by the lengthening of the antero-posterior axis of the eye, by the increased tension of the apparatus with which we adapt our eyes to different distances. The tension is stronger in proportion as the distance is shorter to which the eye is adjusted. If this power is made use of for adjusting the eye continually to a much shorter distance than would be required; i. e., if, in reading or writing, the eyes, instead of at twelve to fifteen inches, are kept at four to six inches' distance from the book, the sclerotic, or membrane which keeps the globe of the eye in shape, giving way by degrees to the pressure, gradually extends antero-posteriorly. Thus the eye becomes oval, and the retina is somewhat removed from the optic media, from the cornea, and the lens. The retina then only receives the images of near objects; distant objects appear undefined, and can only be seen by the aid of concave glasses.

The abnormal posture of children during school-time, and especially while writing, is productive of spinal curvature. Pupils are forced every day, for several hours, to maintain the same unhealthy posture, overtiring always the same muscles, twisting and bending the spine always at the same place, and thus gradually altering the shape and position of the bones. The normal position would be to keep the upper part of the body straight; the shoulder-blades, both of the same height, freely suspended, together with the upper arm, on the ribs, and in no way supporting the body; both elbows on a level with each other, and almost perpendicular under the shoulder-joint, without any support; only the hands and part of the fore-arm resting on the table; the weight of the head freely balanced on the vertebral column, and not on any account bent forward, but only turned so much round its horizontal axis that the face may be inclined sufficiently to prevent the angle at which the eye is fixed on the book from being too pointed.

Dr. Liebreich then presents the following design for school desks. The top of the desk has an inclination of 20° for writing; for reading, a greater inclination is required—about 40°. This latter is obtained by turning up a flap of five inches in width, fixed to the front edge of the desk. All seats have backs, consisting only of a board three inches wide, which, placed at the right height, sufficiently supports the lower joints of the spine, to enable the pupil to keep straight while reading or writing. The distance between the back of the seat and the table can be regulated to the size of the pupils, and is always just sufficient for the flap to come quite near the child when writing.

Floating of Solid in Molten Iron.—In a communication to the *American Journal of Science*, Prof. Adolf Schmidt takes exception to Mr. R. Mallet's explanation of the phenomenon of certain metals in the solid state floating upon a bath of the same metals in a molten state. Mallet assumes the existence of what he terms a "*repellent force*." Prof. Schmidt upsets this assumption by an experiment which he thus describes: "Have a solid ball of cast-iron of one and a half to two inches diameter cast and filed off pretty smoothly. Have a ladle or vessel of at least three-quarter cubic foot capacity filled with molten cast-iron. If, then, you lay the cold cast-iron ball on the surface of the molten iron, you will find that the ball, in spite of the 'repellent force,' assumed by Mr. Mallet, will sink to the bottom of the ladle at once. With an iron rod you can feel the ball at the bottom of the ladle, and roll it about. But, after twenty or thirty seconds, the ball will slowly rise to the surface of the bath and remain there. It is thus evident that cast-iron, at ordinary temperatures, is both *heavier* and *denser* than molten iron, but that, as its temperature rises, the solid iron expands, and becomes lighter, and finally floats on the mol-

ten iron. The latter fact shows simply that solid iron, when at a high temperature, approaching its melting-point, is less dense and lighter than molten iron, which fact again implies that molten iron must undergo a rapid expansion in the moment of its solidification. The extent of this expansion is, however, less than that of the subsequent contraction in cooling, so that the cold iron is again denser than the molten iron."

Growth of Plants within the Egg.—Prof. Panceri's observations and experiments on the production of cryptogamic vegetation in eggs are interesting, from their bearing on the question of spontaneous generation. At Cairo, an ostrich-egg was given him which was still fresh, the air-space having not even been formed. He soon, however, noticed the appearance of dark blotches within the shell, and, having broken it to ascertain the cause, he found that they were produced by the growth of minute fungi. The partisans of spontaneous generation look on such cases as that as an argument in their favor, supposing the shell of an egg to be quite impermeable to germs derived from without. Panceri, on the contrary, has found that the unbroken shell of an egg is permeable to liquids, and that these may introduce germs into the interior. He has, in fact, actually inoculated uncontaminated eggs with a fungus obtained from the interior of one in which it had made its appearance in a way seemingly so mysterious, and which he had cultivated in egg albumen.

Huxley on the Cell-Theory in Physiology.—In seconding a motion of thanks to Prof. Redfern, President of the Biological Section of the British Association, Mr. Huxley said that the promulgation of the cell-theory had as great an effect upon the physiological world as the French Revolution had on the world of politics. Referring to the doctrine promulgated by Schwann and Schleiden, he said that underneath that doctrine there lay the idea which had been established by every further observation, and which remained unassailable, viz., that the living body was not a simple continuous whole, and its action was not the action of a unity, but that it was made up of a multitude of parts, which lived a *quasi*-independent life; and that the body of a man was made up of an enormous multitude of small living particles, each of which, though subordinated and kept together by means referred to by Prof. Redfern, led a *quasi*-independent life, as did the cells of the organic elements of a plant. It was, in fact, the application to animal-structure of the idea which had been previously applied to plant-structure.

The Deep-Sea Bottom.—In the "Preliminary Notes" of the Challenger Expedition, presented to the Royal Society of London by Prof. Wyville Thomson, are to be found some observations on the *Globigerina* and on the sedimentary formations at the bottom of the sea, which mark a substantial advance in the science of these subjects. The globigerina is a minute foraminifer, the shells of which constitute the great bulk of the chalk formation. An ocean sediment known as the "globigerina-ooze" also consists principally of these shells, and hence it is to be regarded as a true chalk formation. Hitherto Prof. Wyville Thomson and Dr. Carpenter have supposed that the globigerina is an inhabitant of the sea-depths, while other English, as well as American and German, naturalists have insisted that it is a surface animal. In these "Preliminary Notes," Prof. Thomson very frankly admits the erroneousness of his own view. In fact, the living globigerina is, he says, very different in appearance from the dead shells we find at the bottom of the sea. In the living animal the shell is clear and transparent, and each of the pores which penetrate it is surrounded by a raised crest, the crest round adjacent pores coalescing with a roughly-hexagonal net-work, so that the pores appear to be at the bottom of an hexagonal pit. At each angle of this hexagon the crest gives off a delicate, flexible, calcareous spine, sometimes four or five times the diameter of the shell in length. These spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long, transparent needles crossing each other in different directions have a very beautiful effect.

The nature of the deposit at the bottom

of the ocean appears to depend upon the depth of the superincumbent water. So universally is this the case that the observers on board of the Challenger needed only to know the depth at any locality in order to foretell the character of mud that would there be brought to the surface by the dredging apparatus. According to Prof. Thomson, "the mean maximum depth at which the globigerina-ooze occurs is about 2,250 fathoms. The mean depth at which we find the transition gray ooze is 2,400 fathoms, and the mean depth of the red-clay soundings is about 2,700 fathoms." These three sedimentary formations, however much they differ from each other, are all the result of the precipitation to the bottom of the dead shells of the globigerina and other surface animals. Why, then, do they differ so much in appearance and in chemical constitution? The globigerina-ooze is 98 per cent. carbonate of lime; the gray ooze consists of carbonate of lime with a greater or less proportion of clay; the red ooze is almost pure clay, viz., silica, alumina, and red oxide of iron. Prof. Thomson accounts for the absence of carbonate of lime from the red clay, and its partial absence from the gray ooze, by the theory that at great depths there is an excess of free carbonic acid. This would convert the carbonate of lime of the shells into a soluble compound. In that case the red clay would be "the insoluble residue, the *ash*, as it were, of the calcareous organisms which form the globigerina-ooze after the calcareous matter has been removed." It is worthy of note that living animals, brought up by the dredge from great depths, have their calcareous shells very rudimentary.

A Ballooning Spider.—A paper of singular interest, by Dr. Lincecum, contributed to the Smithsonian Institution and published in the *American Naturalist*, describes the marvelous art of the gossamer spider in the construction and navigation of her aëronautical ships. In Texas, according to the author, December is the month for these ballooning spiders to emigrate. When they intend to make an ascension, they fix themselves on some extreme point of the branch of a tree, or weed, or corn-tassel, then carefully spin out a lock of white gossamer, five or six inches long and two inches wide in the middle, tapering toward the ends, holding it all the time in the gentle breeze by a thread two or three inches long, which, being attached to the end of the selected point, detains the balloon until it is finished. They then spin out at the bow two lines, thirty or forty feet in length, and another of twenty or thirty feet at the stern, then cut the cable and sail away on an inclined plane. There are a mother and half a dozen or more young spiders aboard every balloon, and thus the species is scattered over vast districts. These tiny aëronauts choose for starting on their voyage a clear day, temperature 60° Fahr., wind gently from the south. At about 1 P. M. they may be seen sailing with the wind. Toward 4 P. M. the spectator will observe that the balloons are beginning to descend. When the streamers strike some tall weed or grass the air-ships are made fast and the passengers instantly leap out, spinning out a thread as they fall, thus landing in safety.

A Demand of Modern Education.—In an address delivered on the occasion of the dedication of Pardee Hall, the scientific school attached to Lafayette College, Prof. Rossiter W. Raymond made some timely remarks upon the absurdity of attempting to complete a young man's education in the same time now as fifty years ago. The enormously-increased demands of modern life, said Prof. Raymond, requiring as they do that a man shall know more things, and know how to do more things, than were formerly sufficient for his reasonable success, are not to be satisfied by a mere change in a few subjects of instruction. It is not enough to substitute one study for another. The period of study must also be prolonged. In recognition of this principle, while it is for the present impracticable to make it an invariable part of a college education, by imperatively increasing the length of the college course, or by raising the standard of admission to colleges, the device of a post-graduate course has been very generally adopted; and it will not be long before experience will demonstrate that those men who have received the most thorough preparatory training are able to overtake and to outstrip in the subsequent race of life

those who started with half-developed powers and half-furnished minds.

Insects and Flowers.—In his lecture at Belfast, on "Common Flowers in Relation to Insects," Sir John Lubbock inquired into the causes of flowers closing their petals during rain, and of some flowers remaining open for a longer or shorter period than others. The habit of closing the petals during rain is obviously an advantage, since it prevents the honey being spoilt or washed away. Everybody, however, has observed that even in fine weather certain flowers close at particular hours. This habit of going to sleep is surely very curious: why should flowers do so; and why should some flowers close at the approach of night, and others not? Moreover, flowers keep different hours. The daisy opens at sunrise and closes at sunset, whence its name *day's eye;* the dandelion opens at seven and closes at five; ear hawkweed is said to wake at eight and go to sleep at two; the scarlet pimpernel wakes at seven and closes soon after two; while *Tropogon pratensis* opens at four in the morning and closes just before twelve, whence its English name "John-go-to-bed-at-noon." Other flowers, on the contrary, open in the evening. Now, it is obvious that flowers which are fertilized by night-flying insects would derive no advantage from being open by day; nay, it would be a distinct disadvantage, as rendering them liable to be robbed of their honey and pollen by insects not capable of fertilizing them. Hence the lecturer believed that the closing of flowers has reference to the habits of insects. In support of this, he observed that wind-fertilized flowers never sleep, and that some of those flowers which attract insects by smell emit their scent at particular hours.

Catching Cold.—We find, in the Detroit *Review of Medicine*, an account of Prof. Rosenthal's researches on the effects of sudden changes of temperature, from which we abstract a few very useful observations. It has long been known that "colds" are produced, not by lowness of temperature, but rather by sudden changes from a higher to a lower. The application of cold to the surface of a healthy animal causes the cutaneous vessels to contract, and then the blood is prevented from circulating in the skin, and confined to the interior of the body, where it does not readily lose its heat, but serves to supply warmth to the vital organs. But, if the animal be exposed to heat, the cutaneous vessels become dilated, and so remain after exposure to cold. The blood is thus exposed in large amount over a wide surface, and becomes rapidly cooled, even though the temperature of the surrounding medium is not very low. A sudden passing from a heated room into the cold outer air rapidly cools the blood below the normal degree. As it returns to the internal organs, it cools them much more quickly than it would have done were not the vessels dilated by previous warmth. Thus a *sudden* cooling of the blood produces an irritating effect, or induces inflammation in a way that a *gradual* alteration would not do. To produce evil results the cooling must be from *above* to *below* the normal temperature. The effect of a chill in causing inflammation may be due partly to the effect of cold on the tissues themselves, and partly to the congestion (hyperæmia) which will occur in some parts when the fluid is driven out of others by the contraction of vessels. Rosenthal lays most stress on the former of these effects. It is a well-known fact that frequent cold bathing or sponging enables one to bear with impunity sudden changes of weather. This is explained by the improved tone of the vessels, produced by the cold applications. Thus, when exposed to heat, they are not so relaxed that they cannot sufficiently contract when necessary.

How Plants are distributed.—Some low ground on the banks of the Delaware, below the city of Philadelphia, having had a quantity of mud from the channel of the river spread over it, two species of plants, *Polygonum Orientale* (an East Indian species), and *Cleome pungens* (a West Indian species), soon made their appearance in great numbers. During a discussion, in the Philadelphia Academy of Sciences, as to the probable origin of the seeds of these plants, Dr. Leidy expressed the opinion that as the ground had long been used as a place of deposit of ships' ballast, the seeds might

have been in the ground previously, and been quickened by the deposit of the mud. Mr. Mechan thought that perhaps the seeds of these plants, protected from air while buried under water, might germinate after exposure to the air. He referred to other cases of the springing up of new plants after the deposit of fresh earth, and suggested a mode of testing the origin of the seeds.

Education and Invention.—There exists a very general belief that great inventions usually come from uneducated men. How erroneous this belief is, at least as regards the art of metallurgy, is well shown by Mr. G. F. Becker, in a lecture delivered in the College of Mines, University of California. Nasmyth, for instance, invented the steam-hammer, without which neither the metallurgist could turn out sound masses of metal of sufficient size for the fabrication of the vast machines now in use for steamships and other purposes, nor the machinist forge them into shape. The crystallization process, and the zinc process for the desilverization of lead, not only enable us to extract at a profit very small proportions of silver and gold, but also produce an admirable quality of lead. Formerly the quality of lead used to depend almost entirely on that of the ore, and the best brands were exported to all parts of the world; now the best of lead may be made from almost any lead-ore. The inventor of the crystallization process, Pattison, was a professional assayer and metallurgist; and Karsten, who invented the zinc process, was a man of great learning and a metallurgist of the first rank. The inventor of the Rachette furnace, "the furnace of the present and probably of the future for lead or copper smelting," is the engineer who controls the whole governmental smelting and mining interests of Russia. Bessemer, the inventor of the process which bears his name, is a man of extensive scientific acquirements; and Siemens, whose most ingenious apparatus for producing very high temperatures has vastly increased our powers of heating iron and steel, of producing all grades of steel, and of distilling zinc, received as perfect an education, scientific and technical, as the world had to offer. It was Faber du Faur, an accomplished Bavarian metallurgist, who first made practical use of the gases which formerly escaped in immense quantities from the tops of blast-furnaces; and the enormous blast-engines, the hoisting-engines, pumps, and hot-blast stoves, often even the roasting-kilns of such establishments, nowadays require no fuel except this long-neglected waste product. Bischof, another engineer, and metallurgical author, was the first to produce gas artificially for smelting purposes; and this was one of the greatest advances ever made in metallurgy. Lundin, a thoroughly educated Swedish metallurgist, has shown how gas may be produced from wet saw-dust, of such power that wrought-iron may be melted with it.

The Temperature of Germination.—Herr F. Haberlandt has published three tables, showing the maximum and minimum germination temperature of all the more important agricultural seeds. He gives the minimum for by far the largest number, including wheat, barley, rye, oats, buckwheat, sugar-beet, linseed, poppy, clover, lucern, peas, rape, and mustard, as below 40.5° Fahr. The minimum for sainfoin, pimpinella, carrot, cumin, sunflower, *Sorghum saccharatum*, *S. vulgare*, and maize, is between 40.5° and 51° Fahr.; for tobacco and gourd, between 51° and 60.4° Fahr.; and for cucumber and melon, the minimum lies betweeen 60.4° and 65.3° Fahr. The second table shows the percentage of seeds germinating at the temperatures 61°, 47°, 88°, 100°, 110°, and 122° Fahr., and the number of hours elapsing before the rootlets reached a length of two millimetres (0.07874 inch). The maximum limit for coriander and marjoram is between 77° and 88° Fahr.; for wheat, rye, barley, oats, English ray-grass, vetches, horse-bean, peas, chick-peas, white-mustard, woad, cabbage, late kohl-rabi, turnip, radish, madder, fennel, carrot, cumin, parsley, poppy, linseed, tobacco, and anise seed, between 88° and 100° Fahr.; for the common bean, lupin, clover, lucern, early kohl-rabi, summer-rape, buckwheat, chicory, sunflower, and some varieties of cabbage, between 100° and 110°; and finally, for maize, *Sorghum vulgare*, panic-grass, turnip-radish, hemp, teasel, gourd, cucumber, and sugar-melon, between 110° and 122° is the maximum. The third table shows the average

growth of the rootlets in two days at different temperatures. In all cases there is increased growth from 61° to 77° Fahr.; in many cases, as grasses, clover, mustard, and linseed, a decrease from 77° to 88° Fahr., and in nearly all cases a decrease from 88° to 100° Fahr.

Poisoned Soils.—Trees have been twice planted in a certain square in London, but in both cases died. Dr. Voelcker was accordingly directed by the Royal Horticultural Society to inquire into the cause of this. On examining the clear, watery solution from treating the soil with distilled water, he found that the soil contained one-tenth per cent. of common salt, and two-tenths per cent. of nitrates. Whenever the amount of chlorine in soil has reached any thing like an appreciable quantity, it exercises an injurious influence. Land, for example, which has been inundated by the sea, will not grow wheat for the next two years, though in the first year cabbages may be grown, and they will withdraw a good deal of salt from the soil. The quantity of nitrates in the soil under examination was remarkable. Usually, this quantity does not reach a proportion that could be expressed otherwise than by a third place of decimals. There was no doubt, according to Dr. Voelcker, that the two saline ingredients mentioned did the mischief. He did not doubt that the presence of the salt and nitrates was due to the fact that the place was constantly used for committing nuisance. In the same way rabbits kill hedges, and it is well known that it is years before grass will grow in their runs.

Anæsthetics and Metaphysics.—Benjamin Paul Blood has written and printed a little book entitled "The Anæsthetics Revelation and the Gist of Philosophy." His idea seems to be that, when the nervous system is twisted out of its normal function by certain poisons, as it springs back great things are revealed; that is, at the moment a person escapes from anæsthetic stupor he gets a glimpse of the "genius of being"—whatever that may be. Mr. Blood wrote to Tennyson about his discovery, and in his reply the poet says: "I have never had any revelations through anæsthetics; but a kind of 'waking trance' (this for lack of a better word) I have frequently had quite up from boyhood when I have been all alone. This has often come upon me through repeating my own name to myself silently till all at once, as it were, out of the intensity of the consciousness of individuality, the individuality itself seemed to dissolve and fade away into boundless being—and this not a confused state, but the clearest of the clearest, the surest of the surest, utterly beyond words—where death was an almost laughable impossibility—the loss of personality (if so it were) seeming no extinction, but only true life."

The Black Death in Egypt.—According to a correspondent of the Paris *Journal des Débats*, writing from Egypt, Europe is threatened with a visitation of the black death. The pestilence is said to be spreading rapidly in the neighborhood of Medina and Mecca, its chief feature being the dreaded "plague-spot," which, once it appears, is the sure sign of a fatal termination. The Egyptian Government is exerting itself to the utmost to prevent the spread of the contagion; but, unfortunately, the Ramadan is at hand, when thousands of Mussulman pilgrims flock to the shrine at Mecca, and it is feared that they will not only help to spread the contagion there, but also bring it back with them to Europe. The greatest anxiety is felt in Italy, on account of its frequent intercourse with Egypt and the coasts of Asia Minor. The only means of averting the danger would be a stringent prohibition to the pilgrims to return direct to the country from which they came; but this measure would require the united action of the European governments, in order to gain the consent of the various Mussulman governments.

The "Voltaic Armadillo."—Regarding the medical use of this contrivance, a leading physician of New York writes us as follows: "I prescribed the voltaic apparatus of Mr. Seibert for one of my patients, a few weeks ago. I have not heard from my patient since, and do not know what effect, if any, resulted. Pulvermacher's chains, I know, have the indorsement of Sir Charles Locock and many other leading physicians

of London; but I know nothing personally of their utility. I intend to try the 'Armadillo' again."

We spoke of the "Armadillo" last month, not from any direct knowledge we have of it, but to correct the advertised statement that THE POPULAR SCIENCE MONTHLY had endorsed it, which was not true.

Address to an Atom.

BY AN UNCOMFORTABLY CONSCIOUS AUTOMATON.

Mysterious particle,
Intangible and most indefinite article,
Which even Science cannot fix or focus;
Are you indeed of all this hocus-pocus,
Mischristened Cosmos, protoplast? If so,
'Tis pity that the happy *status quo*
Of universal dumb inertia ever
Was broken up by vortices or voices.
'Twere surely better far that space had never
Reechoed to objectionable noises,
Or witnessed all this pother
Of biologic bustle, whose chief law seems Bother!
Why could not you,
And all your fellow-motes, far, far too prankful,
In the embraces of the boundless blue
Rest and be thankful?
A plague on all your forces and affinities!
A mob of monads, to my notion,
Surpasses one of demons or divinities
Only while idle. With the earliest motion
Began the immitigable Mischief. Why
Must you in chaos cut those primal capers,
Which were "the promise and the potency"
Of—all the woes that fill our morning papers?
'Tis surely a reflection most unpleasant
To think that all the plagues which haunt the present
Spring from that moment in the hidden past,
When the first molecule, weary at last
Of immemorial motionlessness, stirring,
Jostled his neighbor Atom. What a whirring
Went through astounded space!
Thought pictures a grim grin upon the face
Of him, the Prince of Evil;
Only that then, of course, there was no devil.
At least of the New Creed that's one prime article;
Though I have little doubt
He was incipient in that self-same particle
Whose fidgets caused the first great stirabout.

If Science's "dry light," at its meridian,
Finds men no more than automatic midges
In its cold ray, the history that bridges
The space between us and the first Ascidian
Were better blotted.
To archetypal atoms was allotted
An easier fate than to the complex mass
Of "clever matter," which has dared to pass
For Man, but is, for all its prayers and panics,
A problem in molecular mechanics!
If Conscience be but chemic combination,
And Love a mere molecular affinity;
What boots all Life's superfluous botheration
Of mad and painful dreams, that limn Divinity
On fool-projected limbos? Life's a swindle,
If taken *à la* TYNDALL.
And, let who may in that demoniac war win
("Survival of the fittest!")—yet, as groping
Less anxiously, less fearing, striving, hoping,
An Ape was less a dupe than is a DARWIN.
That Atom must be a misguided duffer
Who'd join a Co.; *alone* it could not suffer.
Why should it long for partnership and pain so?
I would *I* were a monad—I'd remain so;
And as for "nascent thrills" and "ganglia," drat 'em!
They're things for which I should not care—an Atom!

NOTES.

To determine the real value of the "disease-proof potatoes" advertised by seedsmen, the Royal Agricultural Society of England, some time since, offered a prize of £100 for a really disease-proof potato. The conditions were that the potatoes should be tried in twenty different parts of the kingdom for three years. But the committee did not need to continue the experiment for three years; the results obtained in one season were decisive. None of the potatoes resisted the disease. During the period of vigorous growth, in five localities out of the twenty, the disease was virulent in all the varieties, and by the end of the season it had appeared in all the plots.

THE collection of anatomical and physiological preparations made by the late Prof. Jeffries Wyman was in his will bequeathed to the Boston Society of Natural History, on condition that they paid to his heirs the sum of three thousand dollars. The Society promptly accepted the bequest; but, instead of the sum named in the will, of their own accord they paid to the heirs five thousand dollars.

FROM the investigations of Prof. Buckley, State Geologist of TEXAS, it appears that that State has vast deposits of iron and coal, of much greater extent than had been anticipated. Both are of excellent quality, and, in some cases, they occur near together. He has also found an abundance of salt, gypsum, and a wide range of copper-ores. Other valuable minerals are roofing-slate, marble, soapstone, etc.

DR. KOSCH, of Vienna, has discovered a method of making certain colors fire-proof, so that they may be used for painting on china in precisely the tones required. The inventor also employs a special enamel, which he spreads over the surface to be painted on, thus doing away with the irregularities and porosities of the porcelain; the irregular and undue absorption of color is thus prevented. Another invention of Dr. Kosch's is the fusion of gold, silver, and platinum, with bronze, by which the most gorgeous effects are produced.

A NEW method of casting statues in bronze has been discovered by a Venetian founder named Giordani. The advantage of the method consists in the cast being effected in a single operation, no matter how large the model, or how complicated in its form.

DURING the Paleolithic period horses were numerous all over Europe, and formed the basis of human food. In every "find" of that epoch, horses' bones constitute a considerable portion of the animal remains.

But in the next age, the age of polished stone, we find no indications of horse-flesh having been consumed as food. The question is, whether the horse disappeared from Europe just as it did from this continent, and was imported again from abroad.

A NEW mineral, Rivotite (so called in honor of the memory of M. Rivot, late of the Paris School of Mines) has been discovered by X. Ducloux. It occurs in small, irregular masses, dispersed in a yellowish-white chalk, upon the western slope of the Sierra del Cadi, in the Spanish province of Lerida.

SUGAR, now almost one of the necessaries of life, was nearly unknown to Europe before the Crusades. At present, England consumes as much sugar as all the rest of Europe together—more than one pound per week for every man, woman, and child in the United Kingdom. In 1870, the refined cane-sugar, molasses, and syrup, manufactured in the United States was: Sugar, 754,000,000 pounds; molasses, 839,000 gallons; and syrup, 18,000,000 gallons.

A CHARACTERISTIC effect of snake-poison is rapid decomposition of muscular tissue. From Dr. Weir Mitchell's experiments it appears that, after a few hours, the wounded muscle becomes almost diffluent, and assumes a dark color and somewhat jelly-like appearance; under the microscope it has the appearance of a mass of minute granules.

THE "Copley Medal" of the London Royal Society for the year 1874 has been awarded to M. Louis Pasteur for his researches on fermentation and on Pebrine (a disease of the silk-worm); the "Rumford Medal" to J. Norman Lockyer, for his spectroscopic researches on the sun and on the chemical elements; a "Royal Medal" to Prof. William C. Williamson, for his contributions to zoology and paleontology; and a "Royal Medal" to Henry Clifton Sorby, for his researches on slaty cleavage, and on the minute structure of minerals.

THE British Government has decided to send out next spring an expedition to explore the region of the north-pole. The chief command of this expedition is to be intrusted to Captain Nares, at present in command of the Challenger and already a distinguished arctic navigator. It is intended to make the expedition a purely naval one, no person being permitted to join it in any capacity save officers and men of the Royal Navy.

Two German physiologists, Weiske and Wildt, in a series of investigations on goats, have shown that, although the withdrawal of lime or of phosphoric acid from the food of adult animals leads to fatal consequences, yet it has little or no influence on the composition of the bones, and in particular does not make them friable. To determine the same point with regard to young animals, they selected Southdown lambs about ten weeks old. One of these was fed upon food poor in phosphoric acid, a second on food poor in lime, and a third on normal diet. After the lapse of 55 days various bones were analyzed, and the general result was that, just as in adults, so in young animals: no remarkable change was produced in the composition of the several bones by the difference of diet; or, in other words, that the composition of the bones is independent of the nature of the food. The bones were, however, stunted in their growth.

FROM the researches of Schöne on the conduct of ozone and water toward each other, it appears that ozone does not oxidize water; that ozone is absorbed by water in considerable quantity, even at the ordinary temperature; that when ozonized oxygen is conducted through water, the amount of ozone contained in the mixture is diminished; and that ozone in contact with water is slowly changed to ordinary oxygen.

A PATENT has been granted for an India-rubber shoe, or rather *overshoe*, for horses, as it is called by the *Scientific American*. The shoe is made and lined precisely in the same way as the "arctic overshoe," and in fact presents no difference, save in its shape and in its manufacture, from the best quality of India-rubber. Horses suffering from cracked or contracted hoof are soon cured by the use of these elastic shoes. The cost of rubber shoes, as compared with those of iron, is about one-third more, and their weight is about 40 per cent. less.

A CORRESPONDENT of the Department of Agriculture, writing from Stanley County, North Carolina, notes a curious fact observed in growing turnips on land previously sown with the opium-poppy: the turnips came up, but never got beyond the seed-leaf. Repeated sowings on the same lot had the same result. On the other hand, turnips sowed in spots not far removed from the poppies, did very well, and were less annoyed by insect enemies than ever before. "Can it be," asks the correspondent, "that the opium-poppy leaves in the ground elements incompatible with the life of the turnip?"

AT the instance of the German Anthropological Society, statistical information is to be collected from schools and military depots throughout the German Empire, with a view to the solution of the vexed question, whether there are two distinct types of Germans, one tall and fair, the other short and dark.

Dr. Joseph Fraunhofer.